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BLUE MARSH LAKE PROJECT WATER QUALITY DATA REPORT (RCS-DAEN-CWE--ETC(IU)

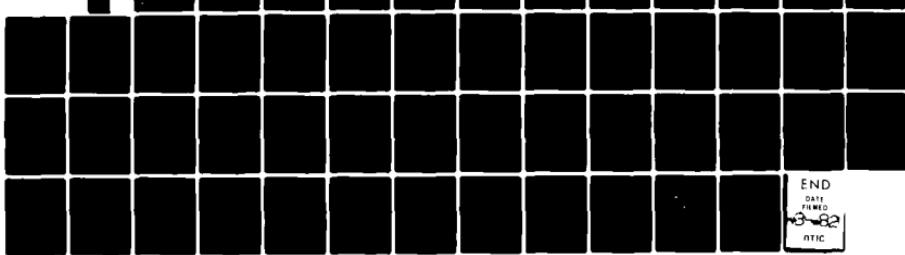
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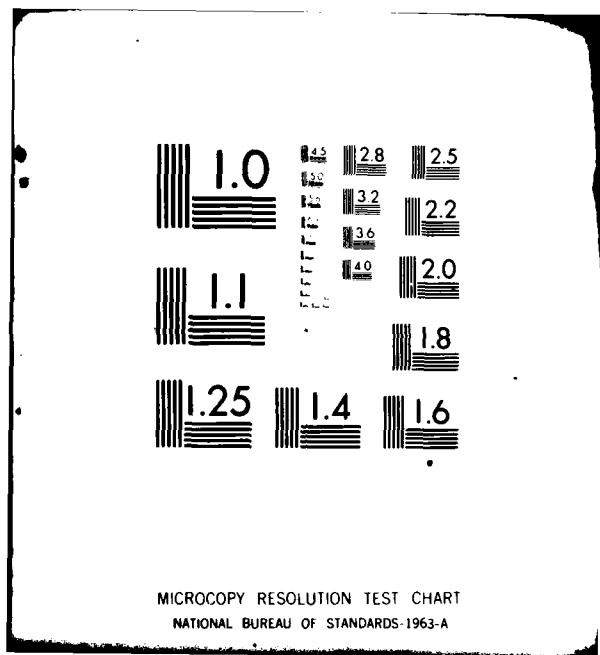
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BLUE MARSH LAKE PROJECT

WATER QUALITY DATA REPORT (RCS DAEN-CWE-15)

Prepared by

U. S. Army Corps of Engineers  
Philadelphia District



FOR THE PERIOD

OCTOBER 1, 1980 TO SEPTEMBER 30, 1981

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SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

The purpose of the report is to present and briefly interpret the water quality data collected to date at Blue Marsh Lake. The analyzed data (Appendix A), meets the standards established by the U.S. Environmental Protection Agency and the Commonwealth of Pennsylvania as outline in Chapter 93, Water Quality Criteria.

The fecal coliform standards for swimming beaches is 200 fecal coliforms per 100 ml of sample and this was not exceeded during the current year.

The report characterizes the general design areas as to land use, potential pollution sources contributing to the lake, the project itself and the relationship between potential water quality problems that may occur and possible effects of the lake on the water quality.

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\* Appendices A, & B are available for inspection in the Philadelphia District office.

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## SECTION I - SUMMARY

1-01. Summary. The Blue Marsh Dam and Reservoir 1/ is located on Tulpehocken Creek, a tributary of the Schuylkill River in Berks County about six miles northwest of Reading, Pennsylvania. The primary purposes of the project are flood control, emergency water supply storage, water quality control and recreation. This report deals with the water quality aspect of the project.

The drainage basin above Blue Marsh Lake consists principally of farmland and woodland with scattered housing located along the rural roads and small villages. Stream valleys within the watershed have moderate to steep slopes, mostly wooded, with adjacent open fields devoted principally to agricultural pursuits. Pollution control in the watershed is problematic, due to the septic tank overflows, lack of sewage systems and drainage from farmlands within the basin.

The pH range for the maintenance of good fish production should be between 6.0 and 9.0. The State pH standards of 6.0 to 9.0 are being met at all tributaries and the main stream. Higher pH levels were found primarily near the water surface level and the pH levels dropped rapidly as testing proceeded from the surface down. It is believed that the alkaline conditions are caused by carbonate material that is picked up as the streams travel through limestone beds and from runoff on local agricultural lands. Farmers using lime and alkaline fertilizers contribute to alkaline runoff that flows into the reservoir. It should be noted here that the high alkalinity is primarily a surface phenomenon and appears to be buffered as depth increases.

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1/ Blue Marsh Dam and Reservoir Location (Plate 1)

This may be due to organic decay of leaves and detritus at depths. This natural acidity would buffer the higher alkalinity. Bicarbonate derived from limestone of the upper Tulpehocken and Spring Creek basin provides for a high buffering capacity of the water for maintaining a pH on the main stem generally between 7.5 and 8.5. Northkill and Liching Creeks, which flow over shale of the Martinsburg Formation, have a lower buffering capacity and a pH between 7 and 8.

Blue Marsh Lake has a wide variety of fish, ranging from bass to game fish such as Tiger muskellunge. Fishing in lake waters was reportedly excellent for 1980. Most fishermen contacted expressed satisfaction with the fishing provided by Blue Marsh Lake.

## SECTION II - INTRODUCTION

2-01. Purpose and Scope. The purpose of the report is to present and briefly interpret the water quality data collected to date at Blue Marsh Lake. The analyzed data (Appendix A), meets the standards established by the U. S. Environmental Protection Agency and the Commonwealth of Pennsylvania as outlined in Chapter 93, Water Quality Criteria.

The fecal coliform standards for swimming beaches is 200 fecal coliforms per 100 ml of sample and this was not exceeded during the current year.

The report characterizes the general design areas as to land use, potential pollution sources contributing to the lake, the project itself and the relationship between potential water quality problems that may occur and possible effects of the lake on the water quality.

2-02. Authority. This report is submitted in accordance with the Corps of Engineers policy authorized in ER 1110-2-334, "Water Quality Management at Corps' Civil Works Facilities", 1 May 1974.

2-03. Background Information. Blue Marsh is located on the Tulpehocken Creek about seven miles northwest of Reading. Blue Marsh Dam, spillway and outlet works was essentially completed in the fall of 1978, and dedicated on 15 July 1979. Flood and water quality gates were closed on 23 April 1979; with the water reaching the summer pool (EL 290) on 16 September 1979. Lake monitoring began on 20 June 1979 by the U. S. Geological Survey, and the District instituted profile monitoring on 13 September 1979. The primary purposes of the reservoir are for flood control, future water supply, water quality and recreation. Blue Marsh Reservoir is one of four flood control structures in the Delaware River Basin.

2-04. Pertinent References. The following references are considered pertinent to this report.

- a. (ER 1110-2-1402)
- b. (ER 1130-2-415)
- c. U. S. Geological Survey, Water Resources Investigations, Water Quality Study of Tulpehocken, Prior to Impoundment of Blue Marsh Lake.
- d. U. S. Geological Survey Water-Resources Investigations (78-53); Bacteriological Water-Quality of Tulpehocken Creek Basin, Berks and Lebanon Counties, Pennsylvania.
- e. Chemical, Bacteriological and Physical Data documented in Appendix B of this report.

### SECTION III - AREA AND PROJECT DESCRIPTION

3-01. River Basin Characteristics. The Blue Marsh project is located in Berks County in southeastern Pennsylvania (see Plate 1). The project is on Tulpehocken Creek, which has its source near the city of Lebanon and flows generally eastward towards its confluence with the Schuylkill River, about

seven miles below the dam site at Reading. The Tulpehocken Creek watershed covers approximately 215 square miles with more than 80 percent of the drainage area located above the dam site. The general topography of the basin is characterized by hills with rounded tops and steep slopes, most of which are wooded.

The watershed is essentially rural and agriculturally oriented with approximately 24 percent of the project lands forested; primarily occurring on steep slopes and along the bottoms of narrow ravines. Urban and villages lands in Myerstown, Womelsdorf, Robesonia, Wernersville, and numerous smaller communities make up the remainder of the Blue Marsh Lake's drainage basin. Reading, which is the county seat, is located approximately 7 miles downstream of the Blue Marsh Dam at the confluence of the Schuylkill River and Tulpehocken Creek.

The project is located in the temperate northeast Atlantic Coast climatic zone, an area of frequent changing temperatures and moderate, year-round precipitation. Precipitation is relatively uniform throughout the year, averaging between about 6.4 and 10.3 percent per month of the yearly total. Snowfall averages about 30 inches per year over the entire Tulpehocken watershed. Temperatures at Blue Marsh Lake area, during July and August, have a daily maximum temperature above 80 degrees. From May through September, the daily average temperature approached 70oF. These temperatures in conjunction with high humidity result in very hot summers.

3-02. Project Description. The principal features of the project are: a dam embankment, a spillway, an outlet works, a service building, an overlook, and two residences for the dam operator's use. Most of the Blue Marsh Lake project's approximately 5,500 acres of Federal land and water and

460 acres of state-owned land will be available for recreation and related uses. The dam is a rock-faced, earth-filled structure across the valley of the Tulpehocken Creek. The dam is about 1,775 feet long with a 30 feet graveled maintenance road along the entire length. The top of the dam is at elevation 332, twenty-five feet above the spillway crest, with 5.6 feet of freeboard above the peak spillway design flood pool. The spillway is an unlined channel through a natural saddle about 1,500 feet south of the dam. The channel is 300 feet wide and approximately 1,360 feet along the centerline. The sill is 300 feet wide, 30 feet long and extends from the crest elevation of 307 to elevation 323.

The outlet works consists of an approach channel, intake tower and service bridge, conduit, stilling basin and exit channel. The intake tower contains the operating house, intakes, gates to regulate intake flow and conduits to convey withdrawals through the dam embankment.

The reservoir, when filled to the recreation pool, elevation 290, is approximately 8.8 miles long and slightly over a mile at its widest point just north of the dam. The average depth is about 25 feet and a maximum depth of 56 feet (summer season pool) near the dam.

The recreation areas are located along the north bank of the reservoir which provide a bathing beach, change house with sanitary facilities, picnic areas and a boat launch area. A second boat launch area is located on the south bank near state hill. The recreation areas were built, maintained and operated by the Army Corps of Engineers. The service building, located on the east embankment near the dam structure, provides office space for management personnel and garage space for project vehicles and equipment.

3-03. Climate. 1/ The project is located in the temperate northeast Atlantic climatic zone, and is characterized by frequent changing temperatures and moderate amounts of precipitation. The area is subject to precipitation from normal rainfall, thunderstorms, and heavy rains associated with hurricanes and snowfall. Based on records compiled by NOAA at Allentown, which is physiographically similar to the Blue Marsh Lake area, July and August have daily maximum temperatures above 80 degrees (F). From May through September average highs of 70°F have been recorded. Snowfall averages about 30 inches per year over the entire Tulpehocken watershed.

3-04. Dam and Lake Characteristics.

a. Embankment. The dam is a rock-faced, earth-filled structure across the valley of the Tulpehocken Creek, about 7 miles northwest of Reading. The top of the dam is surfaced with gravel to serve as a maintenance road. The top of the dam is at elevation 332 with the spillway located through a saddle about 1,500 feet south of the dam. The spillway is an ungated structure with crest at elevation 307.

b. Outlet Works. The outlet works consists of an approach channel, intake tower and service bridge, conduit, stilling basin and exit channel. The intake tower contains the operating house, intakes, gates to regulate intake flow and conduits to convey withdrawals through the embankment.

c. Reservoir. The reservoir when filled to the recreation pool (EL 290), is approximately 8.8 miles long and slightly over a mile at the point of maximum width. The average depth is about 25 feet, and the maximum is 56 feet.

During FY 81 the Philadelphia District was operating Blue Marsh lake for drought contingency water supply purposes. Normal pool elevation during this period (Feb-Sept. 1981) was 290.0. The total water supply storage available was 6.48 billion gallons. During this same period, the pool rule curve was raised from 285 to 290 for drought contingency water supply.

3-05. Geological Patterns. The rocks underlying the Blue Marsh Lake project were deposited as sediment nearly half a billion years ago. After consolidating into solid rock, they underwent folding, and in recent times, the folded strata was exposed by erosion.

Two major layers of sediment crop out beneath the soils of the Blue Marsh project. The Beekmantown limestone group is the older of the two, having been deposited during the lower Ordovician period some 480 to 500 million years ago. The younger rocks are collectively termed the Martinsburg Formation which were deposited during the middle and upper Ordovician period, about 480 to 440 million years ago.

The Beekmantown limestone has been exposed by the erosion of overlying shales in only one place within the project. At the crest of an anticline, the outcrop forms a 5,600 by 1,000 foot oval about 1,800 feet north of the dam. The bedrock in this exposure is encountered within 20 feet of the surface.

The Martinsburg Formation has two divisions: the lower shaly member which underlies most of the project, and the upper sandy member, which rests atop the lower section and underlies only the northwestern portion of the project. The rocks in both divisions occur in numerous layers.

Most of the layers are composed of some kind of shale, but beds of sandstone, limestone and conglomerates also occur. The depth to Martinsburg bedrock varies, but generally averages only 2 to 3 feet. The overburden is somewhat thinner on the ridges and steep slopes but may reach depths as high as 6 feet or more in a few level areas.

3-06. Soils.<sup>1/</sup> The majority of the project's soils are of three series and types. Weikert-Berks shaly silt loam covers about 40 percent of project lands above elevation 290, Litz shaly silt loam covers about 20 percent, and Berks shaly silt loam, about 15 percent. All tend to be somewhat dry, to contain many shale fragments and to be relatively shallow over bedrock.

3-07. Vegetation. Nearly all relatively flat lands and slopes under 15 percent have been cleared and farmed - principally for grass, hay, grain and corn to sustain dairy operations. Woodlands presently account for about 1,400 acres of 24 percent of project lands. They occur primarily on steep slopes and along the bottoms of narrow ravines. The dominant tree species are red oak and white oak. Other major components include black oak, chestnut oak, several hickory species, beech, tulip, hemlock, flowering dogwood, black cherry, white ash, black locust, sassafras, juneberry and red maple.

3-08. Land Use. The Blue Marsh Lake Park comprising of 5,500 acres of Federal Land and water will provide public use areas to accommodate 250,000 recreationists annually. The public use areas presently in use are for picnicking, boating, swimming and hiking. The park and its public use areas were constructed by the U. S. Army Corps of Engineers in 1978 and dedicated in July 1979. The park is managed, operated and maintained by Corps personnel.

The Pennsylvania Fish Commission stocked the lake with various types of game fish and are also responsible for lake management. Management of adjacent lands are under the jurisdiction of the Corps. Most of remaining lands in the watershed are devoted to farming and other closely related pursuits such as orcharding and timbering.

#### SECTION IV - WATER QUALITY DATA

4-01. Purpose of Sampling Program. The purpose of taking water samples is to establish a base line inventory of water quality parameters within the areas influencing and influenced by the lake.

The data that will be collected and documented will be useful in determining the kind of pollutants that may occur in the watershed and within the lake environment. From this date, the Corps through the Pennsylvania ((DER)), can initiate corrective action to control or minimize these sources of pollution. It is the Corps' intent to develop a meaningful water quality program and to conform with the Pennsylvania (DER) standards as outlined in Chapter 93, Water Quality Criteria.

4-02. Testing Procedures and Equipment. The U. S. Geological Survey has conducted pre-impoundment studies 1/ 2/ at the Blue Marsh Project for the Corps. Those investigations dealt with the Biological, Chemical and Physical aspects of the proposed project.

Beginning with the spring of 1979, and filling of the lake, the U. S. Geological Survey initiated a program of collecting lake water samples at prescribed levels at four points within the lake and two points downstream of the dam.

1/ Water Quality Study of Tulpehocken Creek - Water Resources Investigations 77-55, Bacteriological Water-Quality of Tulpehocken Creek Basin Water  
2/ Resources Investigations, 78-53, April 1978.

These samples were analyzed for chemical, biological, bacteriological constituents; - sediment and bed material, for heavy metals. The Philadelphia District continued lake stratification testing in 1980-81. The parameters tested for were dissolved oxygen, pH, temperature and specific conductance. The data results are tabulated in (Appendix A) of this report.

4-03. Data Collected. Considerable data has been collected and documented for future use in project regulation, pollution detection and to initiate protective measures for stream inflows and lake waters to conform with Pennsylvania (DER) Regulations, Chapter 93. A water quality management program was conducted through contract services, with lake stratification testing conducted by the Philadelphia District. This data is available at the Philadelphia District office.

The analysis of water samples suggest the Tulpehocken Creek basin to be a highly fertile environment, evidently caused by runoff which contain large volumes of dissolved fertilizer and animal matter.

Major stream inflows may be included in future sampling and will be analyzed for dissolved oxygen, conductivity, pH, phosphorous, total dissolved solids, nitrate, nitrite, ammonia, temperature and bacteria. On the basis of this accumulated data, the Philadelphia District will evaluate and apply this information in the future management of Blue Marsh Lake.

The Environmental Branch will continue coordination efforts with the Pennsylvania (DER) for the purpose of continuing their assistance in conducting Biological and Chemical Surveys of stream inflows and lake waters at the Blue Marsh Project.

Fecal coliform samples were collected at the beach waters and analyzed. The current fecal coliform standards for swimming beaches is 200 fecal coliforms per 100/ml of sample and this was not exceeded during the 1981 testing period at Blue Marsh Lake.

Since Blue Marsh Lake is relatively new and the water quality data documented to date insufficient, it is problematic to draw precise conclusions regarding water quality conditions at this time. The indications are that minor problems were encountered in algae proliferation in the upper lake area and anerobic conditions were recorded at bottom depths.

#### 4-04. WATER CHEMISTRY

a. Nitrogen and Phosphorous: The concentrations of nitrogen and phosphorous necessary at the beginning of the growing season to produce nuisance populations of algae were suggested by Sawyer (1974) to be 0.30 and 0.015 mg/l respectively. See Appendix B for more discussion.

b. Dissolved Oxygen. The concentration of dissolved oxygen in water in equilibrium with the atmosphere, depends on temperature and dissolved-solids content of the water. The solubility of dissolved oxygen increases as temperatures and dissolved solids decreases. The State has established the minimum dissolved-oxygen concentration necessary for maintaining healthy aquatic life in Tulpehcoke Creek as 5.0 mg/l and a daily mean not less than 6.0 mg/l. Minimum values at all five stations, with 3 exceptions, exceeded these standards, and although it is possible that the daylight sampling program has not disclosed the true minimum values, the criteria are indoubtedly met at all five sampling sites.

This is further discussed in Appendix B.

Stratification monitoring 1/ which began for 1980-81 revealed that anerobic conditions existed from approximately 4 meters to lake bottom throughout the lake until the middle of October. This condition improved during October as indicated by a higher dissolved oxygen readings at the lake bottom near the dam and throughout the lake. Dissolved oxygen readings showed a marked improvement at all four test sites and met the standards as published in Chapter 93, Water Quality Criteria, Pennsylvania DER.

c. pH. The pH range for the maintenance of good game fish production should be between 6.0 and 9.0. Our testing program (Appendix A) indicated that the criteria established by Pennsylvania DER were met at all lake stations during 1980-81. This could be contributed by the bicarbonate derived from limestone of the upper Tulpehocken and Spring Creek basin and is responsible for the high buffering capacity of the water and for maintaining a pH generally between 7.5 and 8.5 throughout the lake.

d. Total Dissolved Solids (TDS) and Specific Conductance. Specific conductance is a measure of the ability of a unit volume of material to conduct electric current. In water, this ability is directly related to the concentration of ions and therefore to the concentration of dissolved solids.

Water-quality criteria for Blue Marsh Lake, (Pennsylvania DER Standards, Chapter 93), require that the monthly average must not exceed 500 mg/l dissolved solids and must not exceed 750 mg/l at any time. Specific conductance data (Appendix B) indicate that these criteria are being met at all four testing sites within the lake (See Appendix B).

4-05. COLIFORM SAMPLING. The coliform counts at Blue Marsh remained within the limits established by the Pennsylvania (DER) of no more than a geometric mean of 200 colonies per 100 millimeters of sample for total coliform. The highest count follows a period of rain, particularly after a prolonged dry spell, indicating that runoff carries material into the water rather than from point sources.

Control of drainage from livestock areas, fencing of creek banks, and diligent monitoring of sewage treatment plants for assessing and correcting deficiencies are necessary in reducing the enteric bacterial populations in the Tulpehocken Creek basin to acceptable levels.

Based upon present enteric bacteria populations, estimated rate of die-off, and theoretical retention time in Blue Marsh Lake; a reduction in bacteria densities to meet water quality standards can be expected during the June-to-September recreation season except during periods of intense rainfall and subsequent runoff.

A meaningful use of fecal streptococci measurements in assessing water quality has been made through the correlation with the fecal coliform data. As reported by Gelreick and Kennerl fecal coliform bacteria are at least 4 times more numerous than fecal streptococci in the feces of man. Conversely, fecal streptococci are at least 1.4 times more numerous than fecal coliform in farm animals, dogs, cats, and rodents.

1/ Gelreick, Edwin E. and Kennerl, Bernard A., 1969, Concepts of fecal streptococci in stream pollution, Journal WPCF, V.41, no. 8, 16p:

A FC/FS ratio of 4 or greater indicates the presence of human waste while a ratio of 0.7 or less is indicative of animal wastes. Ratio's between 0.7 and 4 probably represent a mixture of wastes. A ratio between 2 and 4 suggests a preponderance of human waste, and a ratio between 0.7 and 1-0 suggests a proponderance of livestock and poultry waste. A FC/FS ratio between 1 and 2 is difficult to interpret and may require sampling closer to the source. The correlations of FC/FS are most meaningful when applied to stream samples collected during the initial 24-hour contact with the receiving water.

4-06. ALGAE. The potential for algae bloom remains in the upper reaches of the lake. Concentrations of nitrogen and phosphorous was highest after storm runoff. Based upon estimates from flow duration curves, the annual input of nitrogen and phosphorous to the lake is about 1,400 tons and 46 tons respectively. Further comments are noted in Appendix B.

#### SECTION V - INTERPRETATION OF DATA

5-01. General Post-Impoundment Conditions. Blue Marsh Lake does not have an acid problem. The bicarbonate derived from limestone of the upper Tulpehocken and Spring Creek basin, is responsible for the high buffering capacity of the water. As a result, pH readings between 7.5 and 8.5 are found throughout the lake.

Analysis of data 1/ collected by the Philadelphia District, Betz-Converse & Murdock, Inc. indicates that the water quality of lake waters meets the standards as set forth in the Clean Streams Law, ref. Title 25, Chapter 93. Documented data indicated that generally throughout the summer season, water quality remained good and is acceptable for recreational pursuits.

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1/ Appendix A - Stratification Data.

5-02. Fishery. Blue Marsh Lake is expected to be primarily a walleye-bass lake with crappies, the principal forage fish. Fishermen contacted expressed deep satisfaction with the quantity and size of fish that were taken. Releases were made for an extended period during FY 81 to provide cold water downstream for fishery considerations. These cold water releases were made possible by drawing water from the bottom.

The Pennsylvania Fish Commission is responsible for the stocking management and patrol of the Blue Marsh Lake. The Commission's fish stocking program began in May 1979 and has progressed quite satisfactory this year. Fish were not stocked during FY 81.

#### SECTION VI - RECOMMENDATIONS AND PROPOSED STUDIES

6-01. General. The following recommendations and proposals are made relative to the water quality management and control at Blue Marsh Lake.

- a. Maintain present sampling frequency and proposals are made relative to the water quality in the lake.
- b. Establish tributary and downstream sampling and monitoring for dissolved oxygen, pH, nitrate, nitrite, ammonia, total dissolved solids, ions, total phosphate, specific conductance and bacteria.

c. Coordinate Corps Monitoring activities with Pennsylvania DER's and attempt to secure PA DER's Water Quality Section to initiate Macroinvertebrate and Benthic Invertebrate studies in the tributaries of the Blue Marsh Lake.

d. Correlate data collected from other agencies and establish their sampling points, procedures and equipment used for testing.

e. Continue close cooperation with the Pennsylvania Fish Commission in the management of Blue Marsh Lake and initiate improvement of fish habitat both in the lakes and downstream from the dam sites.

f. Maintain a permanent record system of data on hand and other data obtained from all other sources. Such data will be used as a management tool and provide a means for evaluating water quality trends.

6-02. Findings and Conclusions. The water sampling program will continue to be expanded to include tributary and downstream monitoring.

Bacteriological monitoring will be continued for FY 1982, particularly at the beach area, for compliance with Pennsylvania DER standards for public bathing areas.

Documented data 1/ collected on water quality for Blue Marsh Lake from April through November 1981 indicates that the quality of water remains within the standards established by Pennsylvania DER. During periods of heavy precipitation, there is slight increase in nutrient enrichment and bacteria counts, but this condition dissipates rather quickly with no apparent detrimental effect on water quality.

1/ Appendix A

Previous studies indicate that bicarbonate derived from limestone of the upper Tulpehocken and Spring Creek is responsible for a high buffering capacity of the water and for monitoring a pH of 7.5 and 8.5 in the Blue Marsh Lake. In some cases, the Corps testing program indicated pH readings of 9.0 and higher.

Water Quality Analysis, by BGM (Appendix B) indicated moderate growth of algae and weeds, apparently due to the nutrient enrichment of lake waters caused by runoff.

6-02.(a). FUTURE TRENDS.

Blue Marsh is relatively new, therefore, it is difficult to predict future water quality trends since the lake has not stabilized and there is insufficient recorded data for predictive analysis.

The Philadelphia District began its water quality testing program in June 1979. This program will continue. It has added bacteriological testing at the beach area and plans to add tributaries to the lake waters. Samples for chemical and bacteriological analysis will be collected from various depths at random times during the year and analyzed at Pennsylvania's (DER) laboratories in Harrisburg.

It appears, according to 1981 observations of lake water, that algae and pond weeds may become a future lake problem. Future management efforts should address this problem and recommend proper control methods to minimize these conditions. This is important to note as high levels of nutrients speed up the aging process of the lake.

6-02.(b). Water Supply. The Delaware River Basin Commission (DRBC) and the United States of America agreed to a contract for certain Water Storage space in the Blue Marsh Reservoir. Western Berks Water Authority is presently under contract with the DRBC to take water from the stream until such time as the Authority may elect to connect into the water supply system at the Blue Marsh Dam. The Authority is presently securing its water from the stream, which meets the quality standards as established by Pennsylvania DER, Chapter 93, Water Quality Criteria.

The forty-eight inch water supply pipe is presently not available for direct withdrawal release tower capacity and can cause anoxic conditions at lower lake depths. To aid in limiting this condition, it is suggested to uncap the 48" water supply pipe, install a small auxiliary basin and an energy dissipation device. Either or both sides of the outlet works could then be used to meet reservoir regulation.

6-02.(c). Conclusion. The data recorded from the 1981 water quality testing program at Blue Marsh Lake suggest that the lake exhibits a nutrient rich environment. Nitrogen and phosphate levels were moderately elevated; but the long term effect of this is not known since sufficient data is lacking at this time to draw predictive conclusions.

The testing program revealed very low to zero dissolved oxygen levels at several stations, primarily station nos. 1, 3, and 6. The depths of low oxygen levels fluxuated. Lake turnover took place in October and as a result dissolved oxygen readings improved substantially.

The proliferation of algae and pond weeds may become a future problem with time.

Close monitoring of this condition will be necessary to determine timing and the application of proper control measures. Any control measures will have to be coordinated with the Pennsylvania Fish Commission and the Pennsylvania Bureau of Water Quality. Limited testing for bacteria levels indicate fluxuation of infestation undoubtedly caused by heavy runoff. It appears that the travel time of water from the upper reaches to the beach area was instrumental and the cause of bacterial dieoff. According to bacteriological data recorded from waters at the beach area, the coliform counts were within the limits established by Pennsylvania (DER) for public bathing areas.

APPENDIX A

BLUE MARSH LAKE STRATIFICATION TESTING  
NAPEN-H

APPENDIX B  
BLUE MARSH LAKE, WATER QUALITY  
ANALYSIS, BCM

## BLUE MARSH LAKE WATER QUALITY SAMPLING

### INTRODUCTION

The Philadelphia District of the Corps of Engineers has established a Water Quality Monitoring Program at a numerous lakes within their jurisdiction, in order to ensure that good water quality is maintained and that the Pennsylvania Water Quality Standards outlined in Chapter 93 are being met. Betz-Converse-Murdoch, Inc. (BCM), under contract to the Philadelphia District, has conducted a water chemistry testing program at Blue Marsh Lake for water year 1981 (December 30, 1980 to September 2, 1981). The following report presents the results of the testing program and an analysis of the data.

### SAMPLING PROCEDURES

The Blue Marsh Dam and Reservoir is located on Tulpehocken Creek, a tributary to the Schuylkill River in Berks County, approximately six miles northwest of Reading, Pennsylvania. The following five stations were sampled 14 times during water year 1981; once a month during December, January, February, March, April and September, and twice a month during the summer months:

- BM-1 Water Road (downstream)
- BM-2 State Hill Boat Launch
- BM-3 Spring Creek (just past Brownsville)
- BM-4 Licking Creek (Mt. Pleasant)
- BM-5 Upstream (Tulpehocken Creek from bridge)

At each station, water samples were collected just below the surface, iced, and delivered to the BCM analytical laboratory within 24 hours. They were analyzed for biochemical oxygen demand (BOD<sub>5</sub>), total phosphorus, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen and total dissolved solids. All analysis were performed in accordance with the current procedures approved by the U. S. Environmental Protection Agency. Dissolved oxygen, pH, temperature and conductivity were measured in the field. Water samples were also analyzed for arsenic due to past problems on the Tulpehocken Creek. In addition, lake samples were collected in sterile bottles five times during the year for bacteriological analysis. The drinking water source at Blue Marsh is sampled in April, June and August at the COE headquarters building for bacteriological analysis.

### PENNSYLVANIA WATER QUALITY STANDARDS

The Blue Marsh impoundment is listed as having the protected use for Warm Water Fisheries (WWF) in Pennsylvania Chapter 93 Water Quality Standards. Basins of the Blue Marsh impoundment are listed as trout stocked (TSF). Table 1 presents the Pennsylvania Water Quality Standards for the Blue Marsh impoundment for the parameters analyzed in the 1981 water year sampling program.

### WATER QUALITY RESULTS

Table 2 presents the water quality data collected at the Blue Marsh impoundment during water year 1981. The following figures present plots of BOD<sub>5</sub>, total phosphorus, ammonia, nitrate, total dissolved solids, dissolved oxygen, temperature and conductivity for the five stations. The following is a discussion by parameter of the sampling results.

#### Biochemical Oxygen Demand (BOD) and Dissolved Oxygen

Dissolved oxygen levels were above the 5.0 mg/l State standards for all sampling dates. Dissolved oxygen levels are inversely related to temperature and dissolved solids concentrations resulting in a decrease of oxygen levels during the summer months. Biochemical oxygen demand (BOD<sub>5</sub>) values were generally <5 mg/l, except for a few high levels at Station BM-1 which is downstream of the dam. The relatively high BOD values (8 - 12) were recorded on the following sampling days: June 8, July 7, and September 2. The upstream station (BM-5) had a BOD<sub>5</sub> value of 8 mg/l on August 6. Considering the dates of the elevated BOD levels, it is probable that the results are due to precipitation events rather than lake turnover. There are no stations in the central portions of the lake which would more likely show effects of lake turnover.

#### Nutrients

The concentrations of phosphorus and nitrogen compounds found in the lake are critical to the eutrophication process. High levels of nutrients speed-up the aging process of the lake by excessive growths of algae and/or macrophytes. The concentrations of nitrogen and phosphorus necessary at the beginning of the growing season to produce new populations of algae were suggested by Sawyer (1947) to be 0.30 and 0.015 mg/l, respectively. Vollenweider (1968) states that .02 mg/l of total phosphorus is the eutrophication danger level. Only 4 of the 68 phosphorus values recorded during water year 1981 are less than or equal to 0.02 mg/l. The mean nitrate level recorded as nitrogen was 4.9 mg/l with 16 of the values exceeding 10 mg/l (which is the state standard). The maximum value was 16.7 mg/l recorded July 7, 1981 at the uppermost end of the lake (Station BM-5).

Ammonia concentrations are important in lake dynamics not only because they serve as a nutrient source, but because un-ionized ammonia can be toxic to aquatic organisms. Although there is no state standard for ammonia in the Blue Marsh impoundment, concentrations greater than 0.5 mg/l could cause problems depending on the water temperature at the time. Ammonia levels exceeded 0.5 mg/l four times at Station BM-1 and once at Station BM-3.

It is apparent from the nitrogen and phosphorus data that the Blue Marsh impoundment is receiving excessive nutrient loadings. If this condition continues, the lake may be severely degraded.

#### Total Dissolved Solids and Conductivity

Specific conductance is a measure of the ability of the unit volume of material to conduct electric current. In water this ability is directly related to the concentrations of ions, and therefore is related to the concentration of dissolved solids. Water quality criteria for the Blue Marsh impoundment require that the monthly average total dissolved solids not exceed 500 mg/l or that it exceeds 750 mg/l at any one time. The data show that these standards were exceeded once on January 14, 1981 and again on February 25, 1981. However, the exceedingly high values recorded on these dates (2,270 to 3,370) may be a sampling anomaly especially since conductivity levels remained fairly low on those dates.

#### Arsenic

Arsenic was sampled at the Blue Marsh impoundment due to previously recorded high levels. Twelve arsenic samples were taken during water year 1981. March and April samples were not analyzed for arsenic due to a misunderstanding. The Pennsylvania standard for arsenic in the Blue Marsh impoundment is 0.05 mg/l. All arsenic levels recorded during water year 1981 are less than the state's standard.

#### pH

The pH values range from 6.0 to 8.5. These values are within the state standards.

#### Bacteria

Samples were collected at all four stations above the dam on March 26, May 26, June 23, July 21, and August 6 for analysis of fecal coliform, total coliform and fecal streptococcus. The state bacteria standard only applies to fecal coliform which is 200 per 100 milliliters during the swimming season. This standard was exceeded at all stations but BM-2, which is the State Hill Boat Launch. Fecal coliform to fecal streptococcus ratios are commonly used as an indicator of the bacterial source. Ratios greater than 4 are said to indicate human pollution while those less than 0.7 indicate animal contamination. Coliform/streptococcus ratios vary considerably at the Blue Marsh impoundment, but the high ratios may indicate some human sources of contamination towards the upper end of the lake. The drinking water samples yielded no evidence of bacterial contamination.

#### SUMMARY

The Blue Marsh impoundment shows relatively poor water quality based on analysis during water year 1981. High levels of nutrients and bacteria were recorded as well as high total dissolved solids values indicating excessive input to the lake. The high dissolved oxygen levels recorded are probably due to super-saturation conditions existing in mid-day, and do not reflect the possibly low diurnal oxygen sags.

RECOMMENDATIONS

Due to the relatively poor water quality found in Blue Marsh impoundment, it is recommended that the following studies be done:

- A watershed analysis to determine the sources of the excessive nutrients and bacterial contamination. This would involve land use analysis, computer modeling of nutrients and bacterial inputs and assessment of suspected sources. A management plan should be developed in order to protect the future recreational value of the lake.
- Precipitation data should be reviewed and used to calculate nutrient loadings at particular times. The data can also be used to explain anomalies in other parameters.
- The previously collected water quality data should be stored in a computerized data management system so that annual trends can be assessed and a more meaningful analysis conducted.
- Additional bacterial sampling should be instituted to trace the source of possible human contamination in Tulpehocken Creek above the lake.

Literature Cited:

Sawyer C. N 1947. Fertilization of Lakes by agricultural and urban drainage. New England Water Works Association. G1: 109-127.

Vollenweider, R. A. 1968. The scientific basis of lake and stream eutrophication, with particular reference to phosphorus and nitrogen as eutrophication factors. Tech. Rep. OECD, Paris DAS/DSI/68; 27: 1-182.

TABLE 1  
PENNSYLVANIA WATER QUALITY STANDARDS  
Blue Marsh Impoundment

Phosphorus (Total Soluble as P) - Not more than 0.03 mg/l

Copper - Not to exceed 0.1 mg/l

Dissolved Oxygen - Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l. For the epilimnion of lakes, ponds and impoundments, minimum daily average of 5.0 mg/l, no value less than 4.0 mg/l.

Arsenic - Not to exceed 0.05 mg/l

Bacteria - During the swimming season (May 1 through September 30), the fecal coliform level shall not exceed a geometric mean of 200 per 100 milliliters (ml), based on five consecutive samples, each sample collected on different days; for the remainder of the year, the fecal coliform level shall not exceed a geometric mean of 2,000 per 100 ml based on five consecutive samples collected on different days.

Nitrite plus Nitrate - Not to exceed 10 mg/l as nitrogen

pH - Not less than 6.0 and not more than 9.0

Temperature - No rise when ambient temperature is 87°F or above; not more than a 5°F rise above ambient temperature until stream temperature reaches 87°F; not to be changed by more than 2°F during any one-hour period.

Total Dissolved Solids - Not more than 500 mg/l as a monthly average value; not more than 750 mg/l at any one time.

Source: PA Chapter 93 Water Quality Standards, Title 25, Part 1, Subpart C. Adopted August 21, 1979.

Table 2

## BLUE MARSH LAKE WATER QUALITY SAMPLING

MM/DD/YY	SITE	BOD	TP-P	NH3-N	NO3-N	NO2-N	DS	DO	pH	TEMP	COND	AS	FC	TC	FS
12/30/80	1	3	0.08	0.09	2.10	<0.10	237	13.6	6.2	3.0	346	<0.001			
12/30/80	2	3	0.06	0.06	1.60	<0.10	210	11.2	6.2	2.0	286	<0.001			
12/30/80	3	2	0.68	1.90	2.45	<0.10	277	12.0	8.2	3.0	375	<0.001			
12/30/80	4	<2	0.15	0.06	3.90	<0.10	202	12.8	7.4	4.0	258	<0.001			
12/30/80	5	<2	0.15	0.15	4.10	<0.10	268	13.6	7.3	2.0	394	0.003			
01/14/81	1	<2	0.06	<0.01	0.30	<0.10	52	11.2	7.0	1.0	29	<0.001			
01/14/81	2	2	0.03	0.01	0.23	<0.10	39	10.0	6.0	1.0	29	<0.001			
01/14/81	3	<2	0.11	<0.01	0.23	<0.10	48	12.2	7.5	2.0	29	<0.001			
01/14/81	4	<2	0.12	<0.01	0.23	<0.10	2270	11.5	6.3	1.0	30	0.002			
01/14/81	5	<2	0.08	<0.01	0.23	<0.10	53	12.2	6.7	2.0	30	<0.001			
02/25/81	1	<2	0.12	0.30	3.42	<0.10	3370	15.0	7.0	4.5	225	0.003			
02/25/81	2	<2	0.10	0.20	3.00	<0.10	207	8.8	7.2	8.0	185	<0.001			
02/25/81	3	<2	0.11	0.10	3.68	<0.14	168	11.8	6.8	9.0	140	<0.003			
02/25/81	4	<2	0.20	0.08	4.34	<0.10	220	11.6	6.6	7.5	210	<0.001			
02/25/81	5	<2	0.13	0.30	3.15	<0.10	228	11.2	7.0	5.5	90	<0.001			
03/26/81	1	<2	0.10	0.10	3.31	<0.10	225	13.8	6.9	5.0	220				
03/26/81	2	<2	0.10	0.10	3.82	<0.10	217	12.1	7.1	5.0	200				
03/26/81	3	<2	0.40		2.38	<0.10	231	10.2	7.1	4.0	250				
03/26/81	4	<2	0.02		4.27	<0.10	285	15.0	7.1	6.0	210				
03/26/81	5	<2	0.13	0.01	3.43	<0.10	199	12.6	6.8	7.0	275				
04/28/81	1	<3	0.04	<0.01	3.43	<0.10	192	13.5	7.0	15.0	320				
04/28/81	2	<3	0.04	<0.01	3.43	<0.10	192	13.5	7.0	14.0	190				
04/28/81	3	<2	0.27	0.30	2.38	<0.10	231	10.2	7.1	12.0	260				
04/28/81	4	<3	0.09	<0.01	3.93	<0.10	192	10.2	7.0	13.0	200				
04/28/81	5	<3	0.08	0.02	2.48	<0.10	103	13.2	6.8	14.0	250				
05/12/81	1	<3	0.04	0.05	3.28	<0.10	219	11.7	7.6	14.0	290				
05/12/81	2	<3	0.05	<0.01	3.25	<0.10	210	10.6	8.2	16.5	305	0.009			
05/12/81	3	<3	0.40	0.23	1.88	<0.10	181	8.9	6.9	240	0.009				
05/12/81	4	<3	0.06	<0.01	3.25	<0.10	204	9.9	7.8	18.0	300	0.007			
05/12/81	5	<3	0.27	0.08	1.37	<0.10	11	9.2	6.6	16.0	125	0.008			
05/26/81	1	<3	0.07	0.14	11.60	<0.10	184	10.4	7.8	19.0	360	0.001			
05/26/81	2	<3	0.09	0.09	6.60	<0.10	195	10.2	8.5	22.0	360	0.007			
05/26/81	3	<3	0.60	0.26	5.80	<0.10	202	8.6	7.4	19.0	410	0.007			
05/26/81	4	<3	0.15	0.27	6.40	<0.10	151	6.7	7.2	25.0	365	<0.001			
05/26/81	5	<3	0.08	0.12	4.80	<0.10	97	7.2	7.3	21.0	195	0.007			
06/08/81	1	8	0.06	0.11	11.90	<0.10	175	10.4	7.6	20.0	360	0.007			
06/08/81	2	3	0.08	0.08	11.30	<0.10	201	8.0	8.0	22.5	365	0.008			
06/08/81	3	4	0.38	0.36	10.90	<0.10	251	9.0	7.2	16.0	440	<0.001			
06/08/81	4	3	0.08	0.15	11.20	<0.10	186	6.8	7.7	22.5	390	0.008			
06/08/81	5	4	0.30	0.23	10.90	<0.10	229	6.4	6.9	21.0	390	0.007			
06/23/81	1	<3	0.03	0.38	11.60	<0.10	203	8.4	6.9	18.0	350	0.007			
06/23/81	2	3	0.02	0.02	11.10	<0.10	219	8.3	8.3	24.0	355	0.007			
06/23/81	3	4	0.44	0.23	11.60	<0.10	215	8.6	7.6	18.0	370	0.007			
06/23/81	4	4	0.10	0.03	11.10	<0.10	210	9.1	8.0	24.0	360	<0.001			
06/23/81	5	5	0.18	0.05	13.30	<0.10	159	8.5	7.5	19.0	210	0.007			
07/07/81	1	10	<0.01	0.54	10.40	<0.10	228	8.5	7.2	20.0	370	0.010			
07/07/81	2	3	<0.01	0.05	10.30	<0.10	216	8.0	8.2	25.0	350	0.008			
07/07/81	3	4	0.42	0.14	11.90	<0.10	225	9.1	7.4	19.0	360	0.008			
07/07/81	4	3	0.04	0.04	10.30	<0.10	202	9.4	8.1	24.0	340	0.009			
07/07/81	5	3	0.13	0.05	16.70	<0.10	154	9.4	7.2	19.0	210	0.009			

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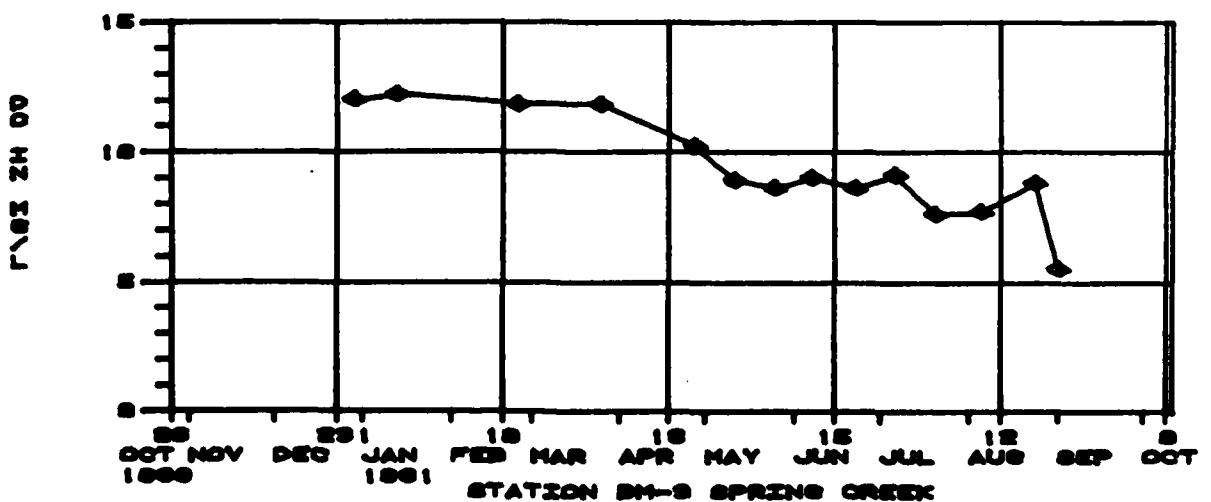
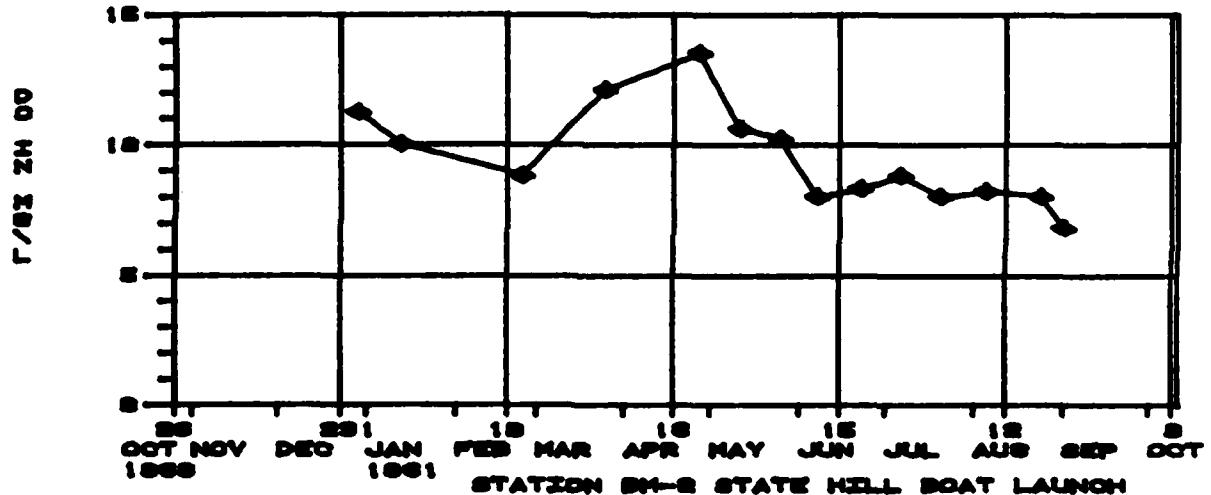
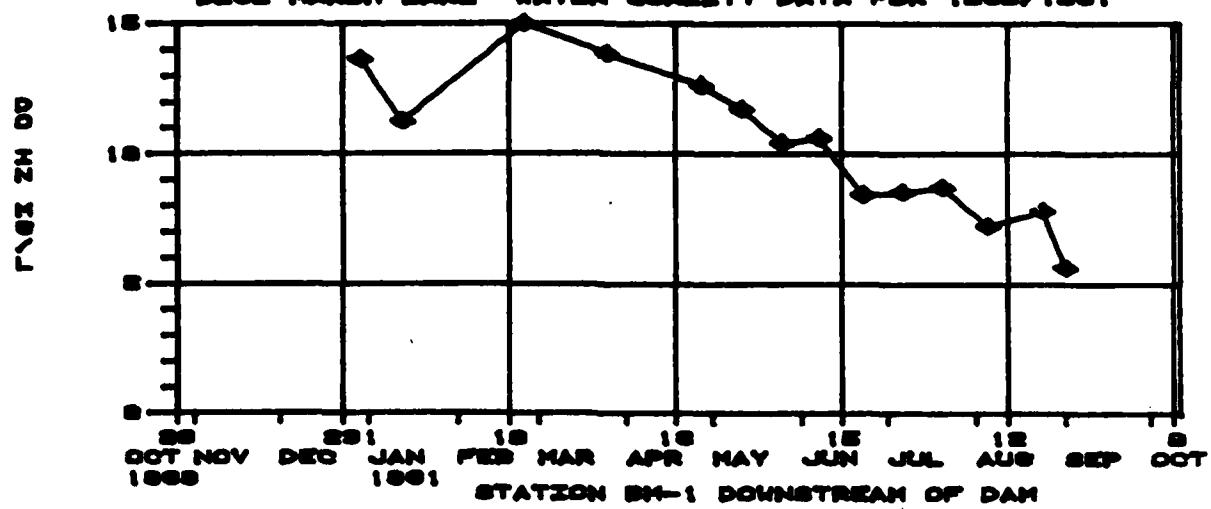
Table 2  
BLUE MARSH LAKE WATER QUALITY SAMPLING  
(Continued)

MM/DD/YY	SITE	BOD	TP-P	NH3-N	NO2-N	DS	DO	pH	TEMP	COND	AS	FC	TC	FS
07/21/81	1	3	0.04	0.52	2.04	<0.10	20.3	8.7	6.9	21.0	295	0.008	0	10
07/21/81	2	3	0.04	0.11	1.71	<0.10	18.6	8.0	7.8	27.0	305	0.002	>8000	20
07/21/81	3	3	0.45	0.23	1.77	<0.10	18.3	7.6	7.2	23.0	340	<0.001	>8000	2300
07/21/81	4	3	0.09	0.08	1.76	<0.10	19.1	8.0	6.6	29.0	260	0.003	>8000	440
07/21/81	5	4	0.18	0.15	1.50	<0.10	85	8.1	6.6	23.0	140	<0.001	>8000	4800
08/06/81	1	<2	0.25	0.68	1.47	<0.10	18.5	7.2	7.5	22.0	260	0.005	100	1200
08/06/81	2	<2	0.08	0.06	1.66	<0.10	18.0	8.2	8.4	25.0	235	0.001	50	7000
08/06/81	3	<2	0.58	0.21	2.39	<0.10	27.2	7.7	7.8	21.0	315	0.001	4700	13000
08/06/81	4	3	0.07	0.06	1.34	<0.10	14.0	7.9	8.1	25.0	240	<0.001	40	1000
08/06/81	5	9	0.22	0.07	1.53	<0.10	17.2	8.8	8.4	25.0	240	0.003	90	1000
08/25/81	1	<3	0.07	0.89	2.03	0.18	348	7.8	6.9	22.0	295	0.010		
08/25/81	2	3	0.03	0.04	3.00	<0.10	30.3	8.0	8.0	23.0	130	0.006		
08/25/81	3	<3	0.67	0.40	4.71	0.23	27.9	8.8	7.4	23.0	230	0.009		
08/25/81	4	5	0.04	0.03	2.51	<0.10	20.8	8.8	7.9	23.0	110	0.012		
08/25/81	5	<3	0.17	0.21	4.34	<0.10	22.1	7.3	7.6	20.0	220	0.015		
09/02/81	1	12	0.20	1.10	2.20	0.13	20.5	5.6	7.8	21.0	320	0.001		
09/02/81	2	3	0.06	0.01	2.62	<0.10	19.0	6.8	8.5	24.0	265	<0.001		
09/02/81	3	<3	0.97	0.67	4.24	0.25	23.2	5.5	7.7	23.0	250	<0.001		
09/02/81	4	5	0.10	0.02	2.42	<0.10	16.8	8.2	8.1	24.0	240	<0.001		
09/02/81	5	3	0.92	0.66	4.27	0.21	28.0	5.8	7.6	22.0	280	<0.001		

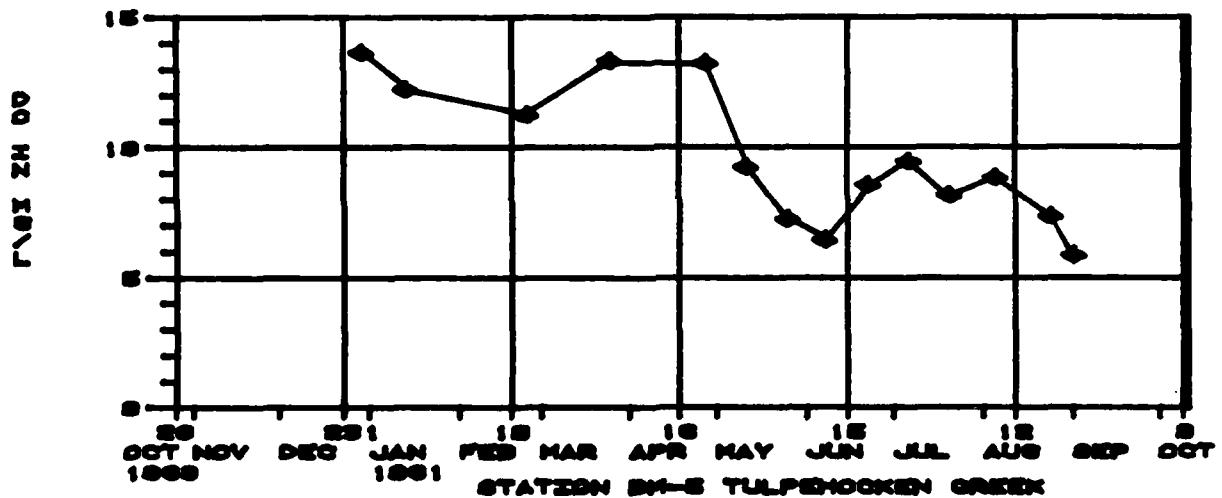
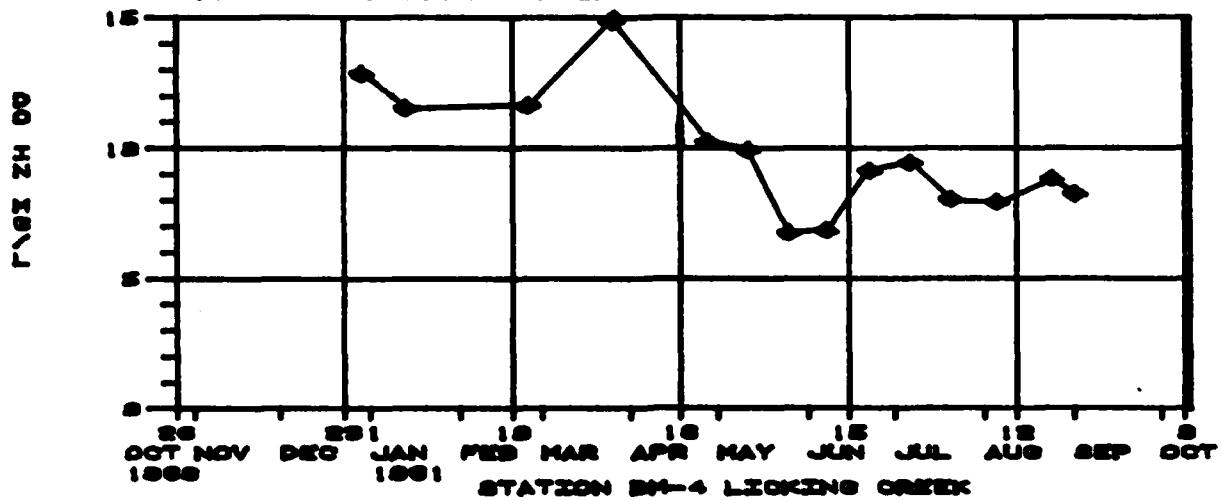
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 MINIMUM           2.0    0.01    0.01   0.23      11    5.5    1.0    29  
 RANGE            10.0   0.96    1.89   16.47    3359   9.5    28.0   411  
 MEAN            3.2    0.18    0.20   4.89      272    9.7    15.8   258  
 STAN DEV        1.8    0.21    0.30   4.06      461    2.3    8.2   101

All units are  $\text{mg/l}$  except: pH in standard units, Temp in degrees centigrade, Conductivity in  $\mu\text{hos/cm}$  and the bacteriological results in  $\#/\text{100 ml}$ .

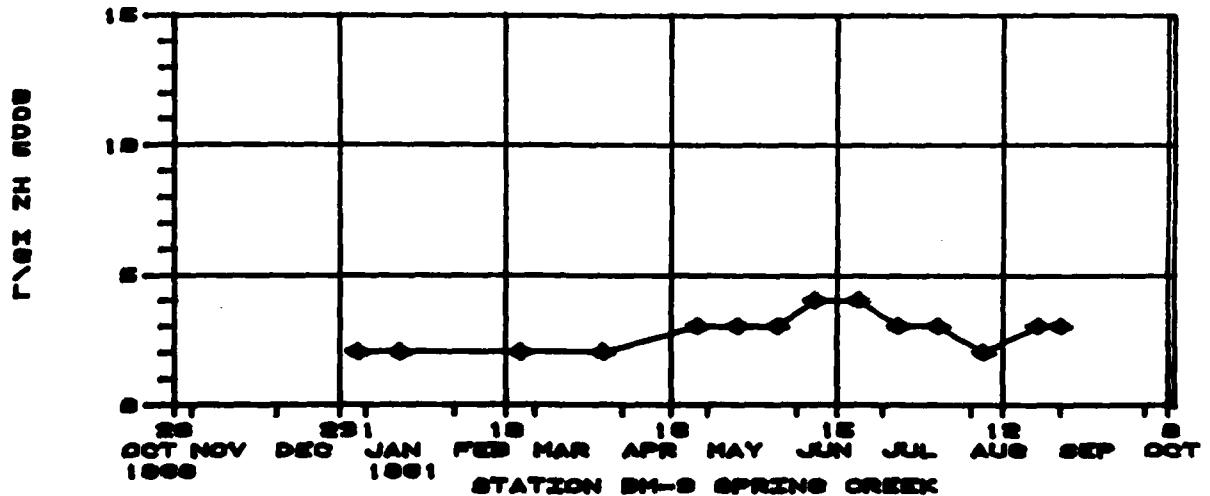
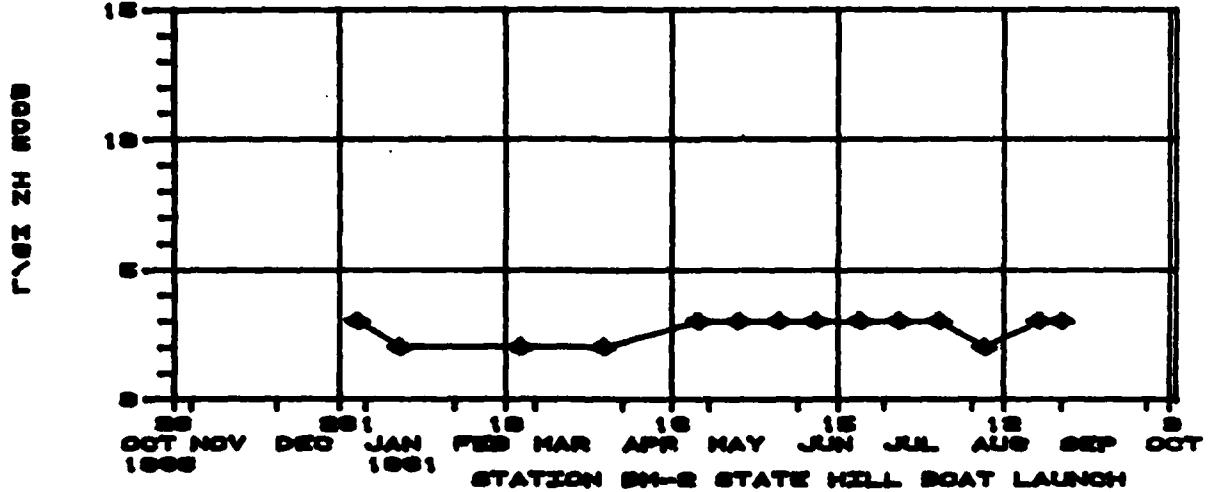
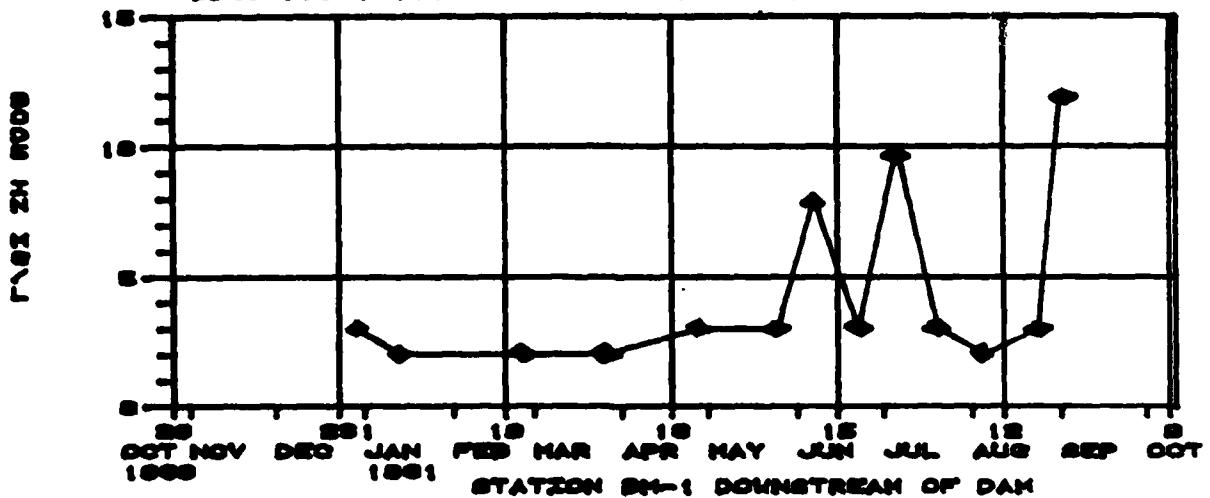
BLUE MARSH LAKE WATER QUALITY DATA FOR 1980/1981



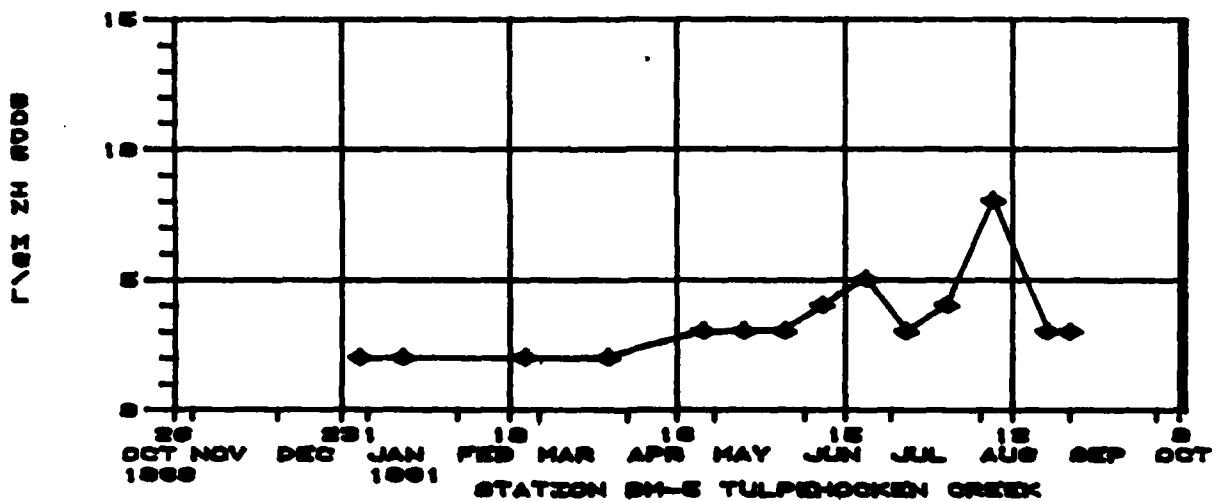
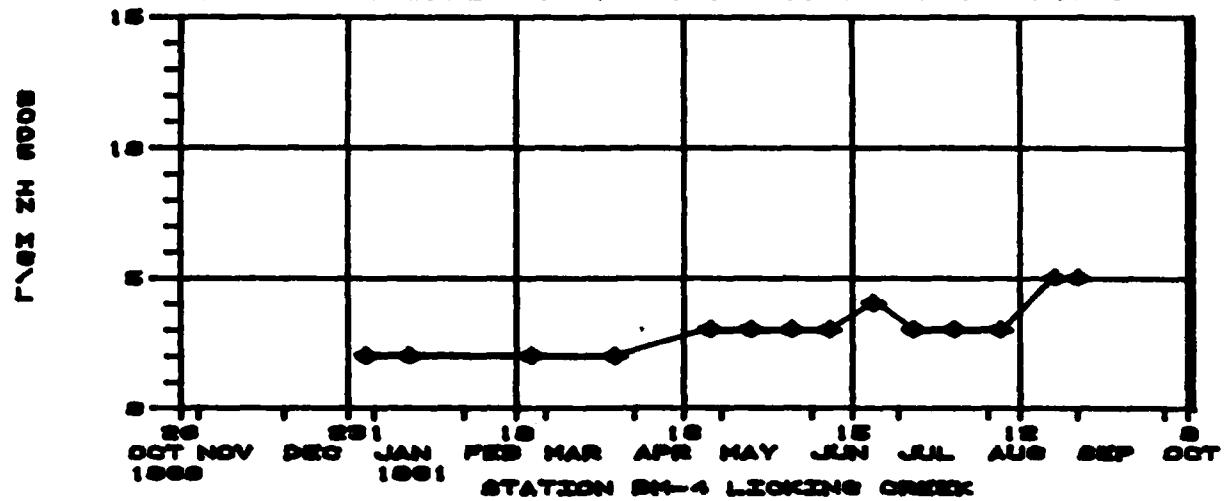
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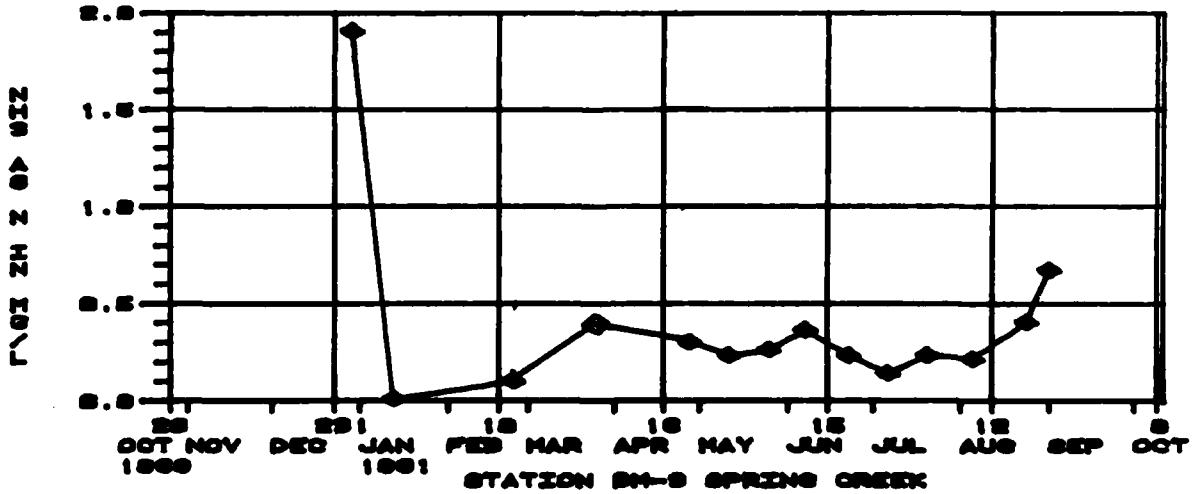
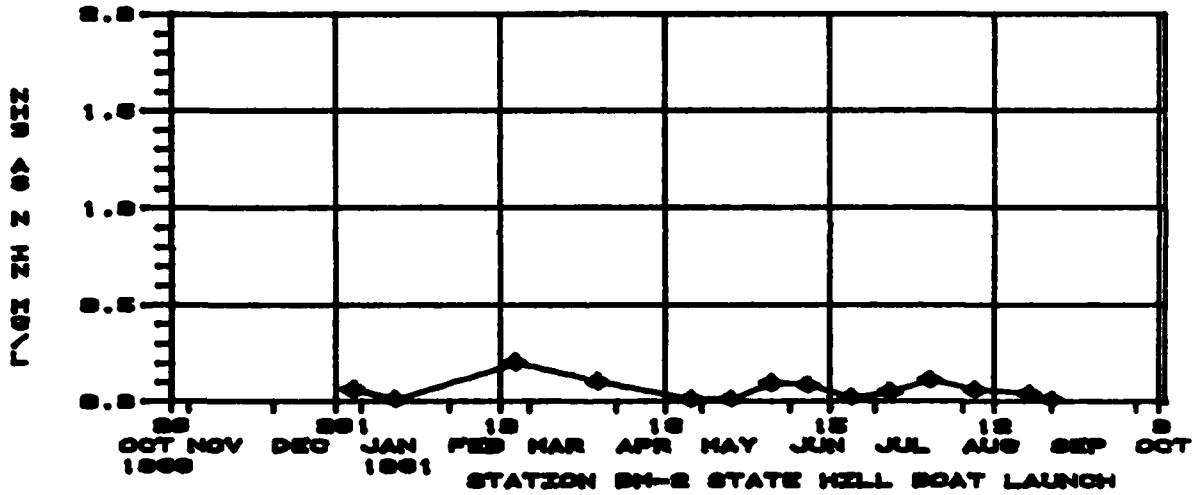
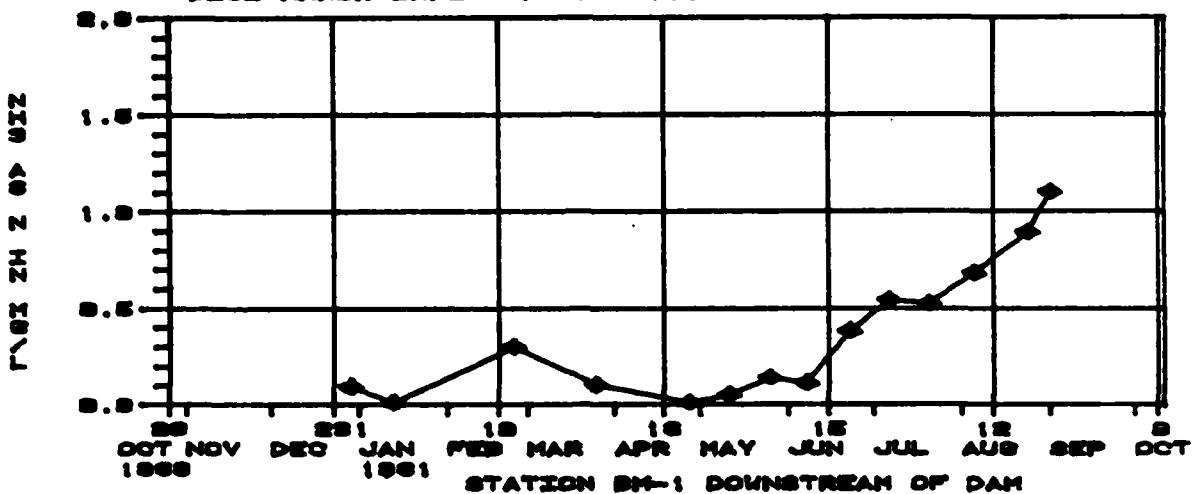
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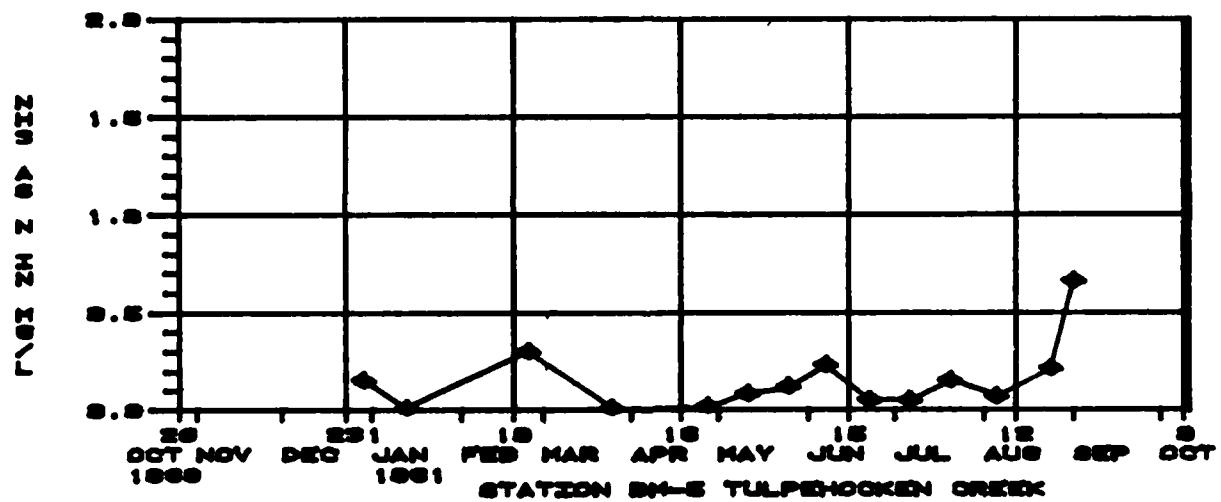
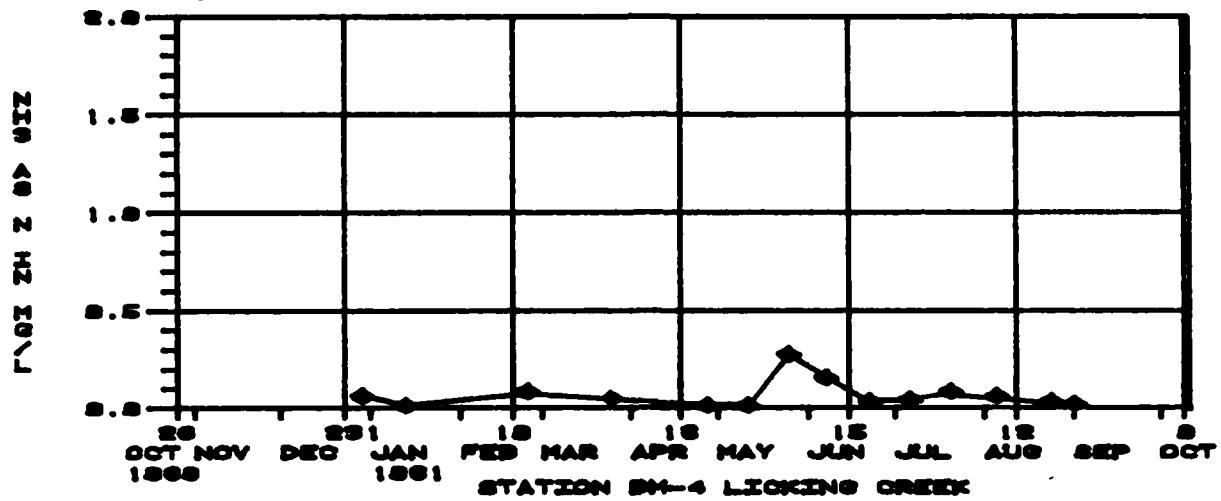
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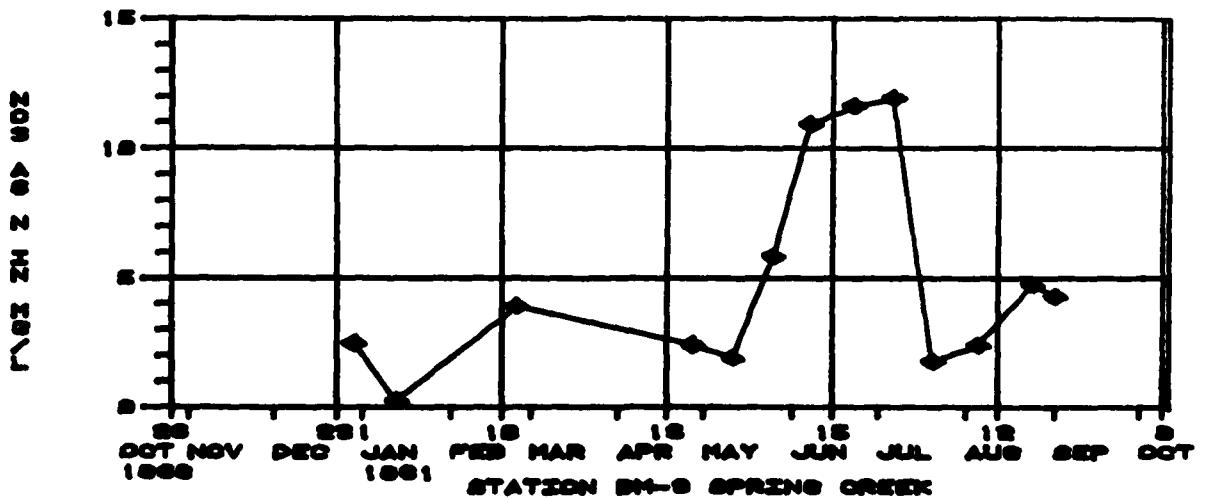
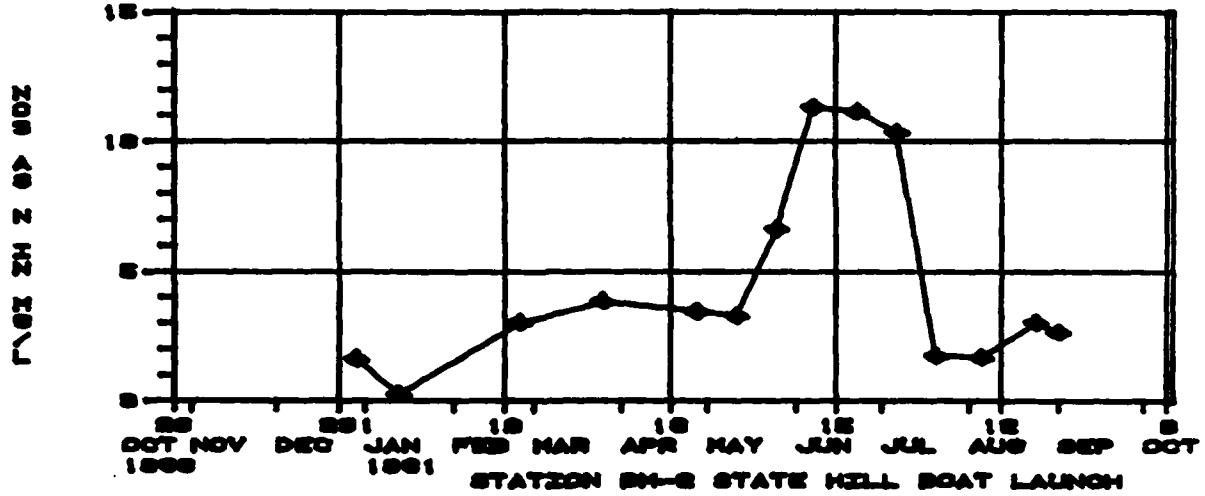
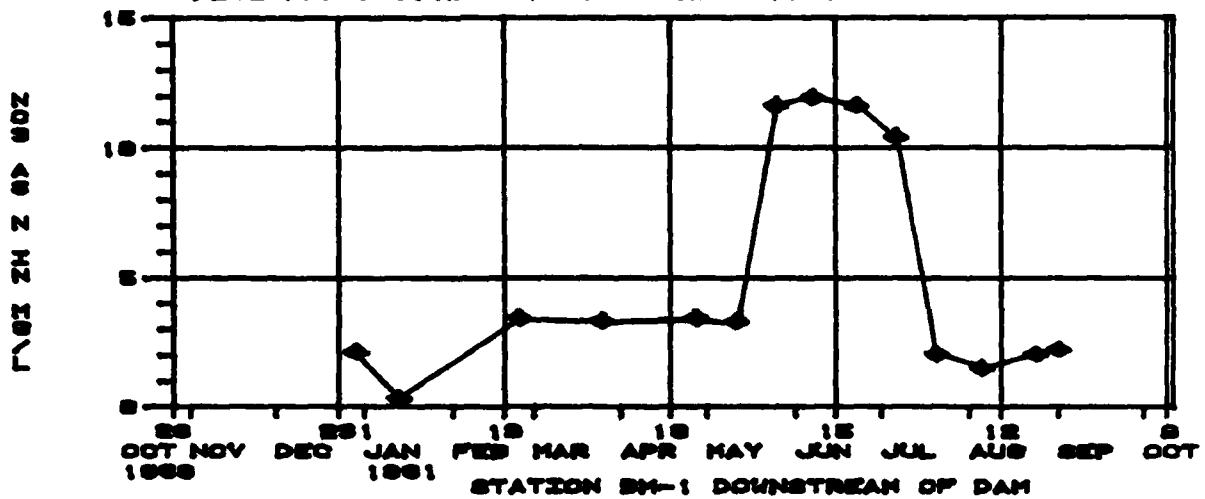
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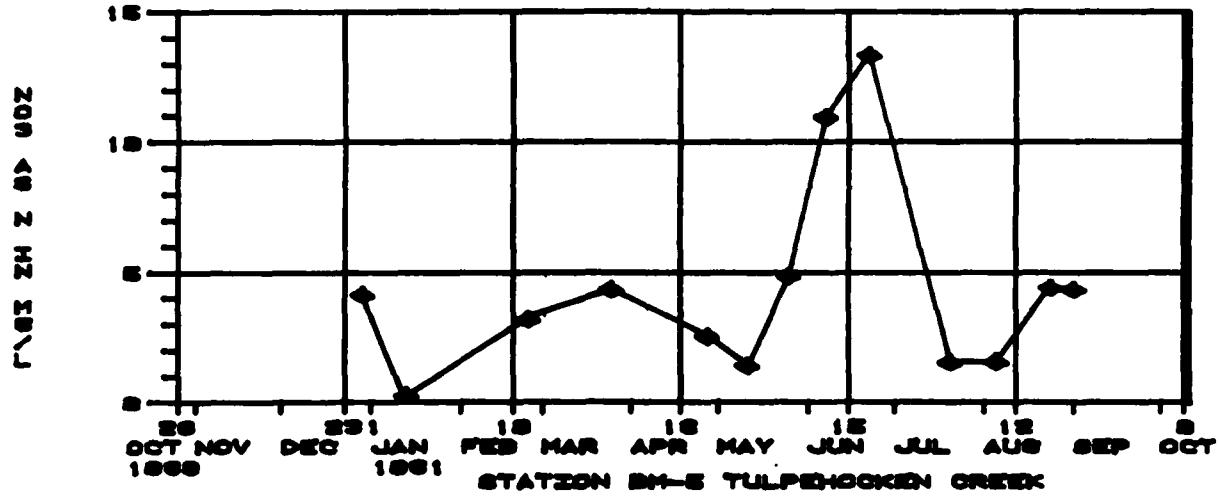
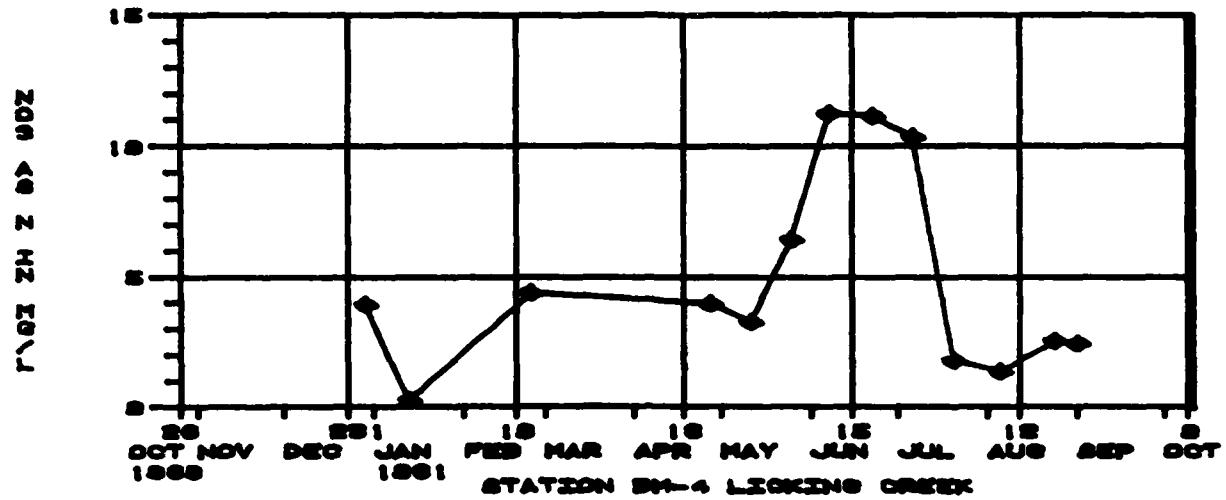
BLUE MARSH LAKE WATER QUALITY DATA FOR 1980/1981



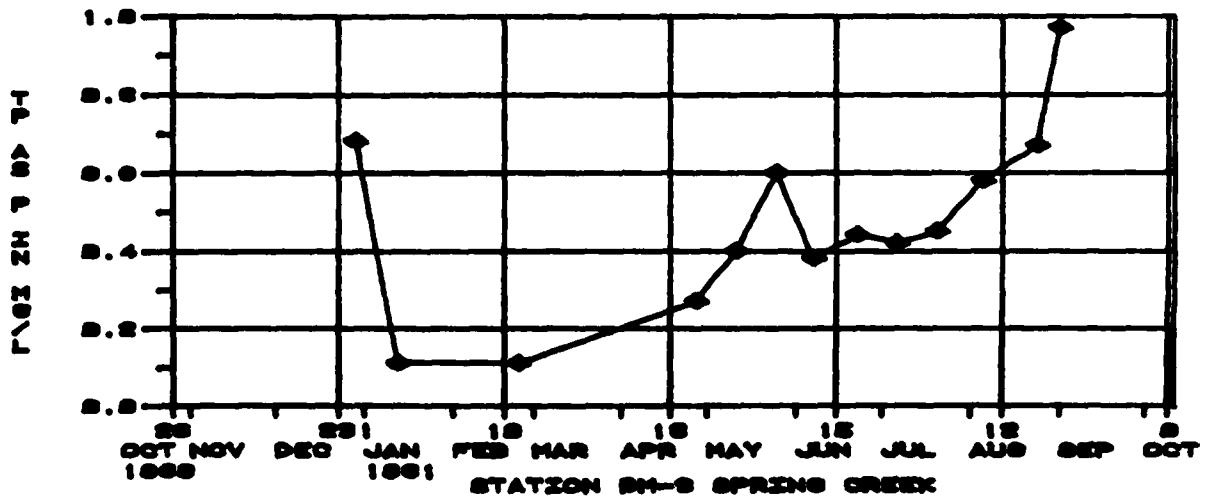
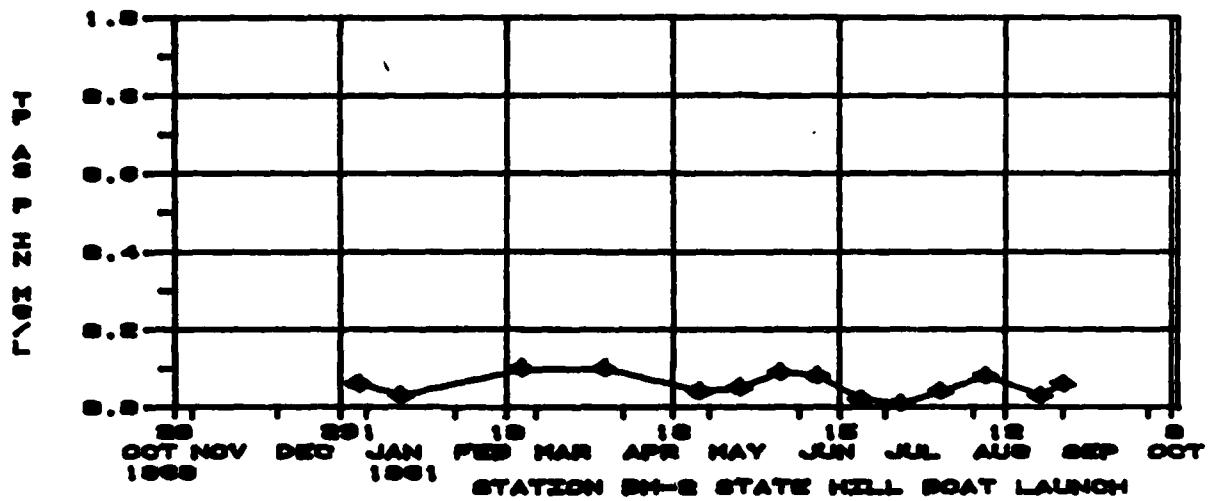
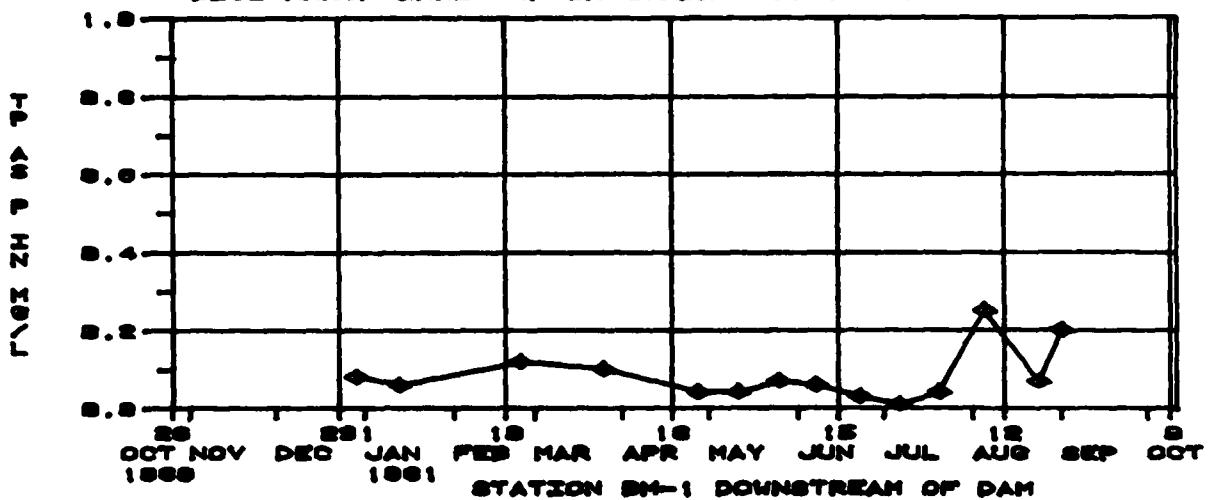
BLUE MARSH LAKE WATER QUALITY DATA FOR 1980/1981



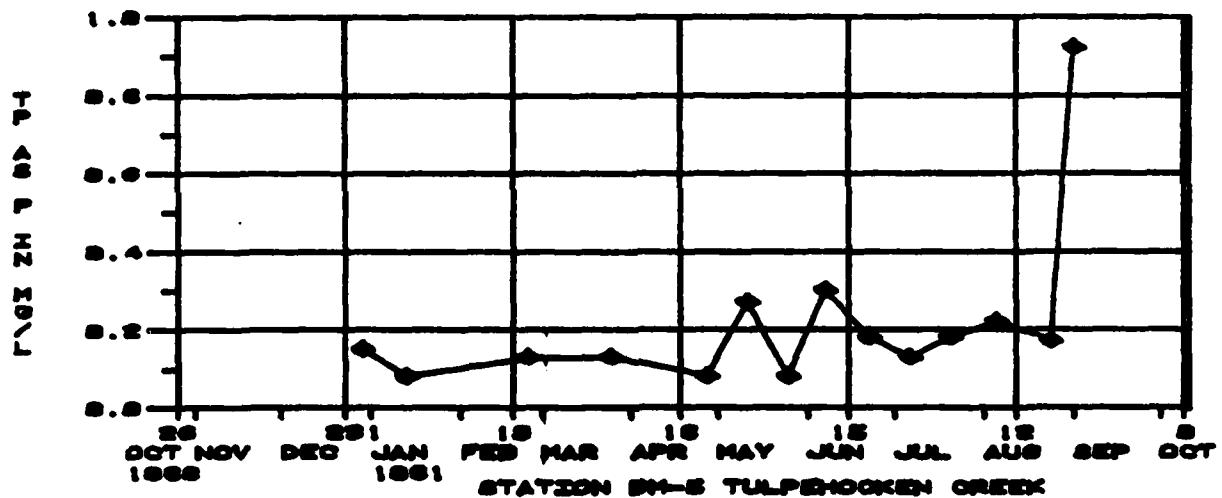
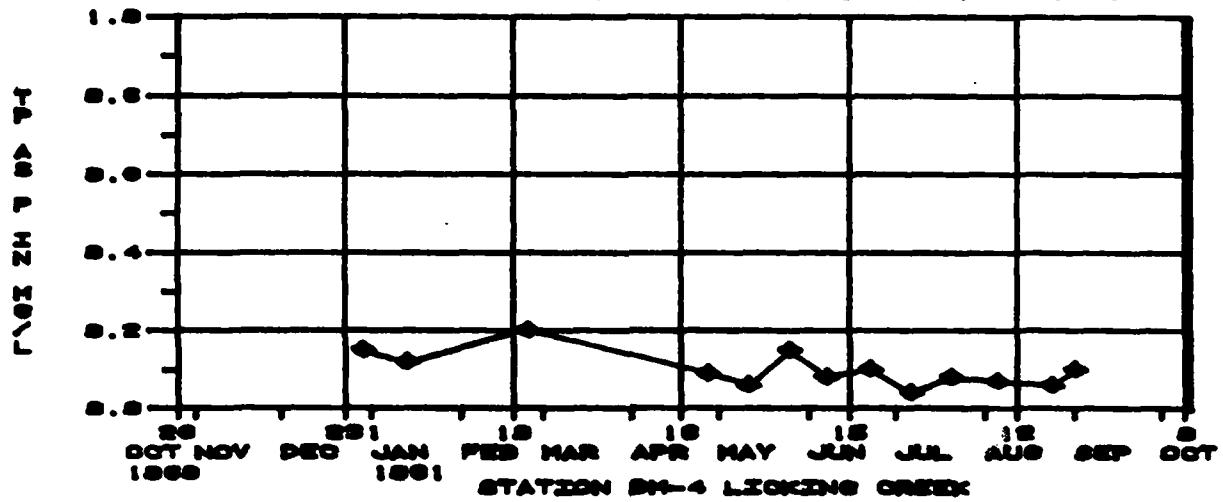
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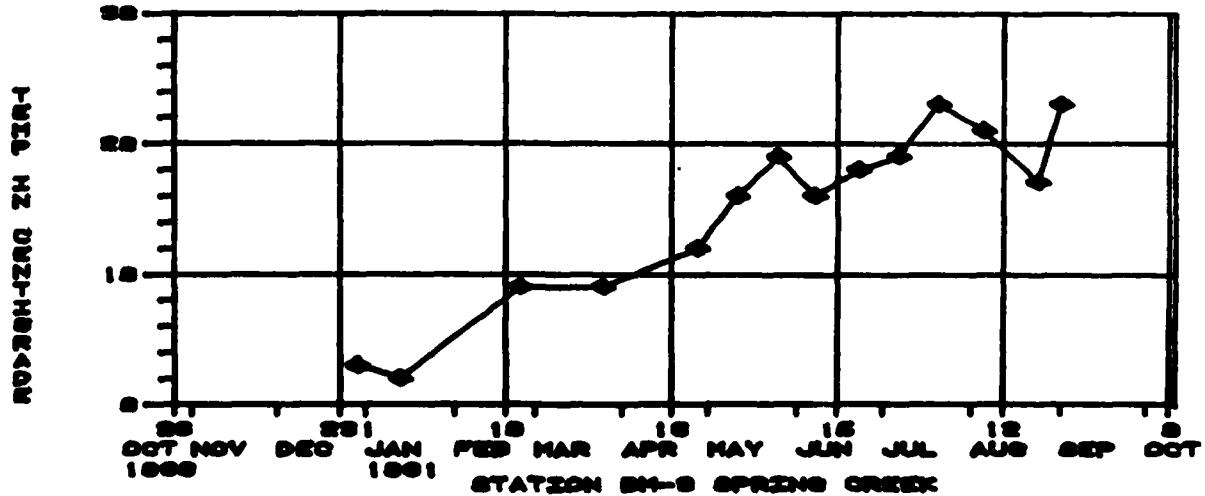
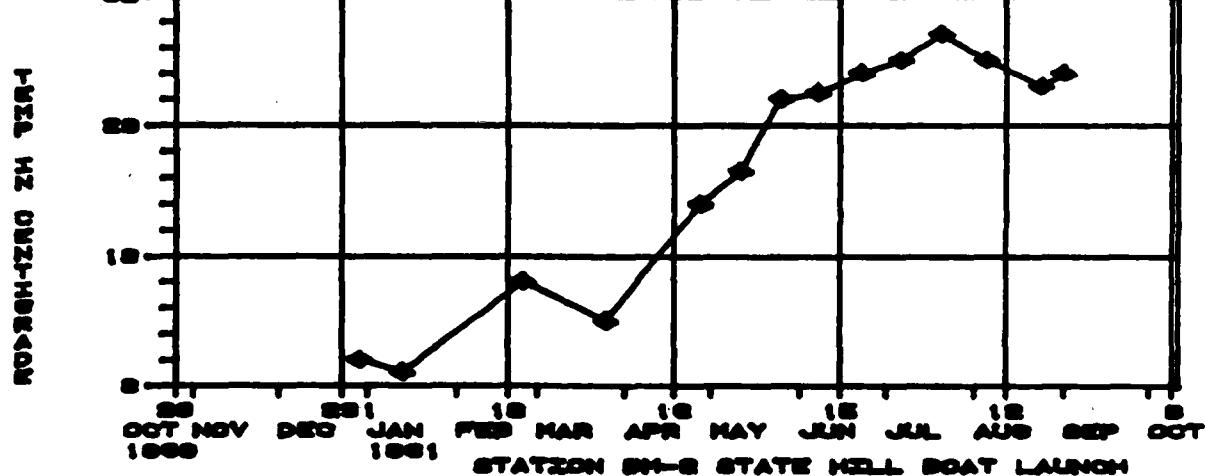
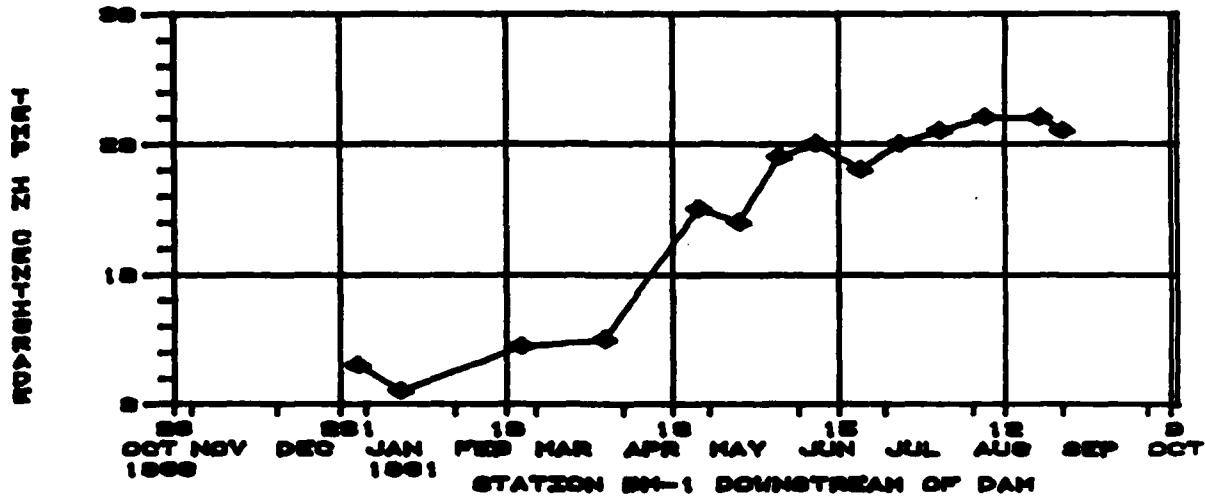
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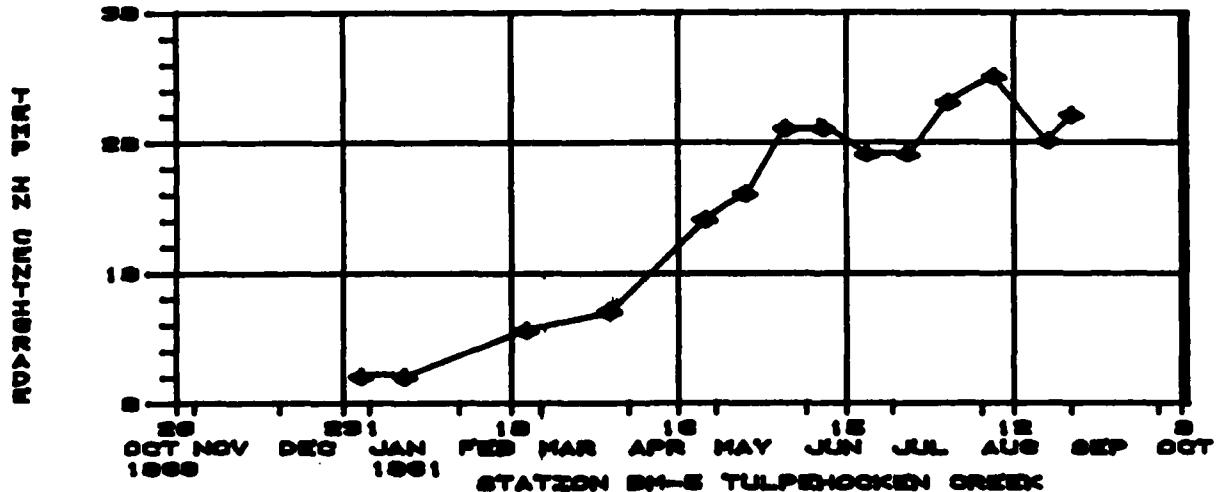
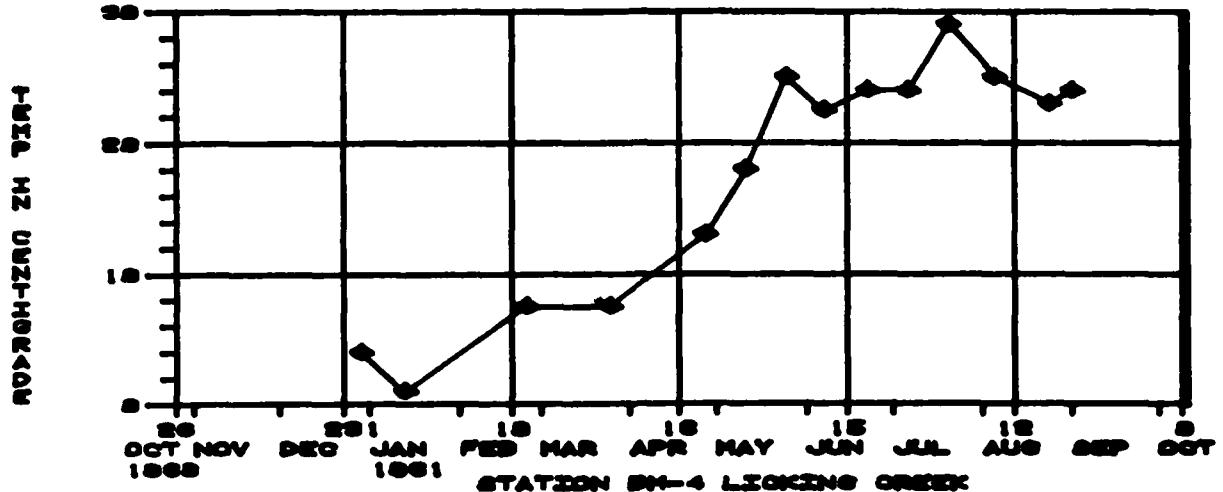
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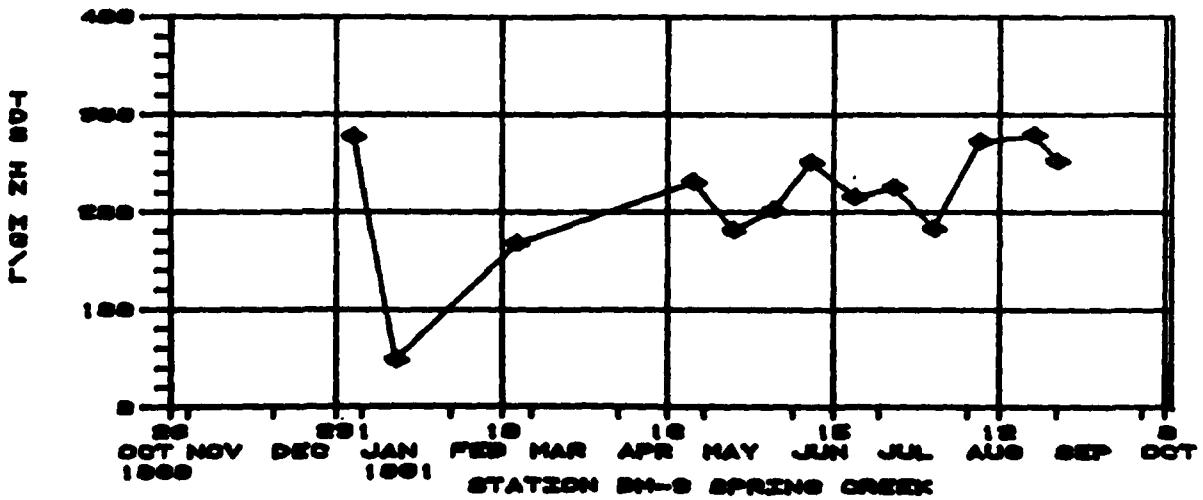
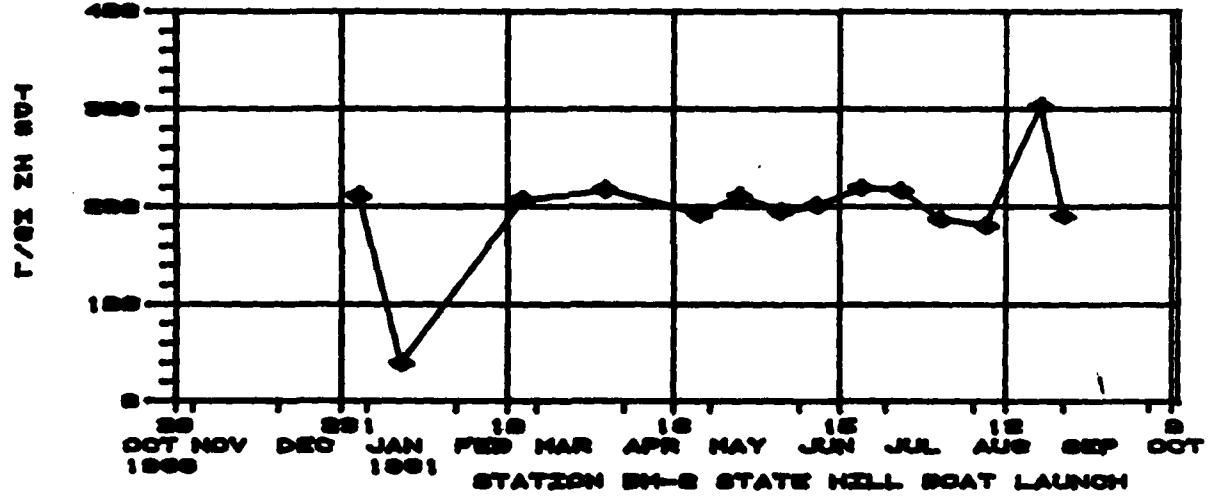
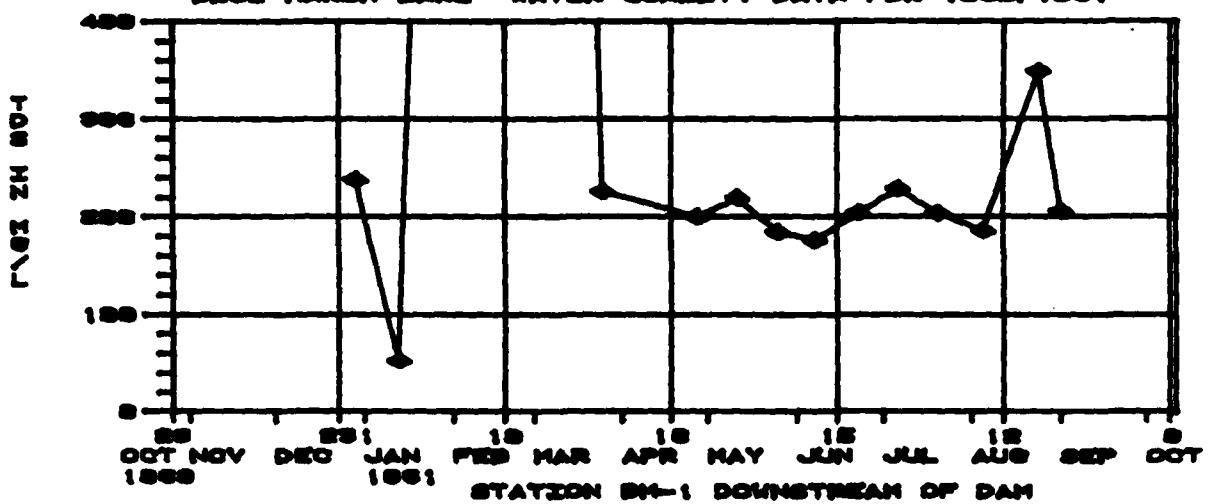
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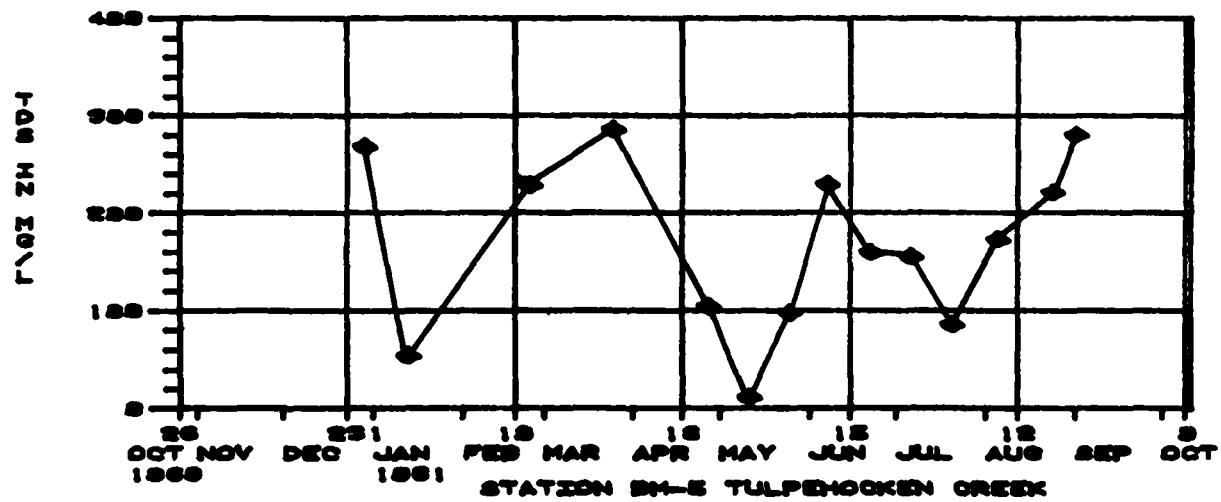
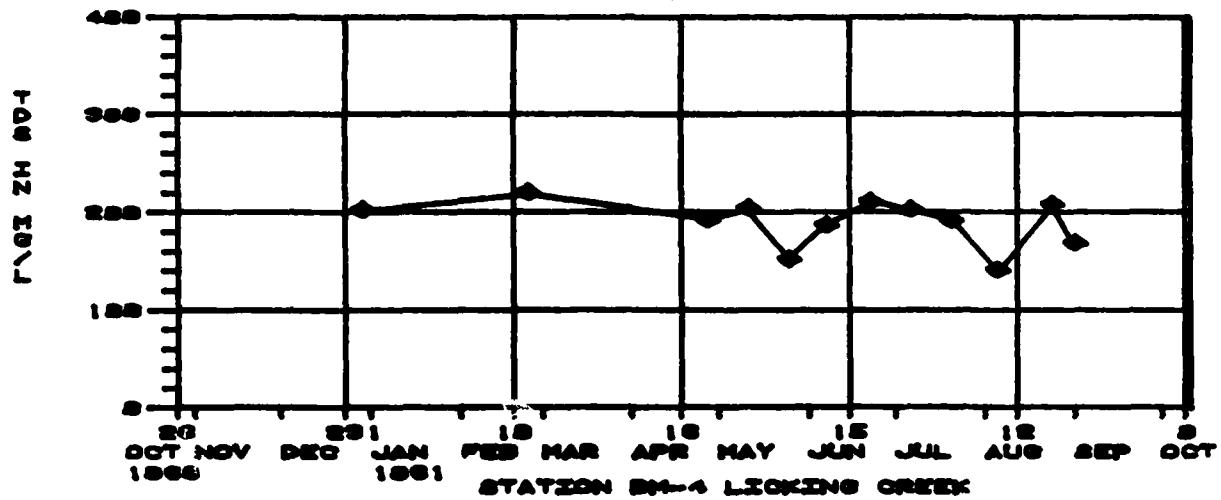
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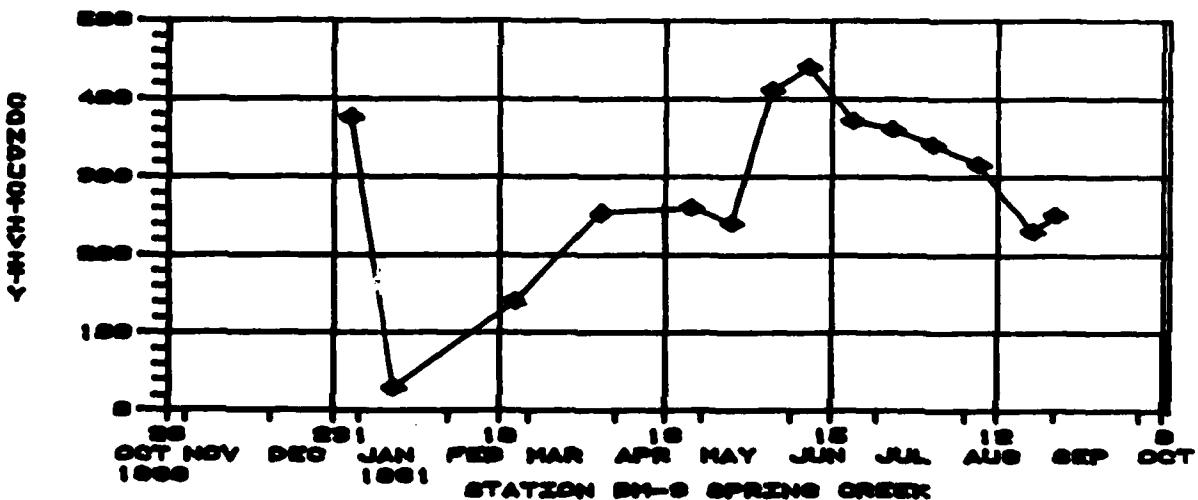
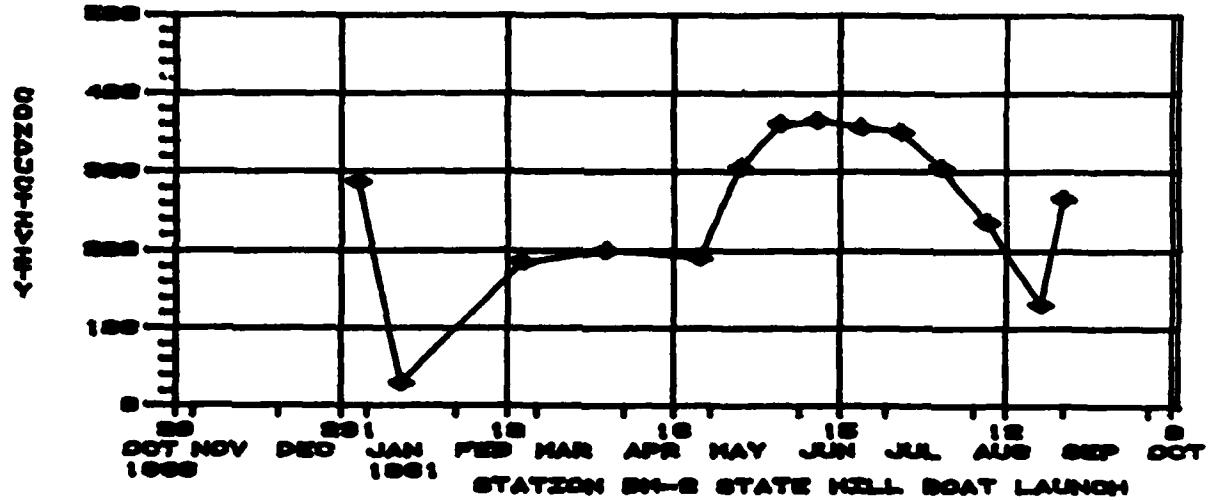
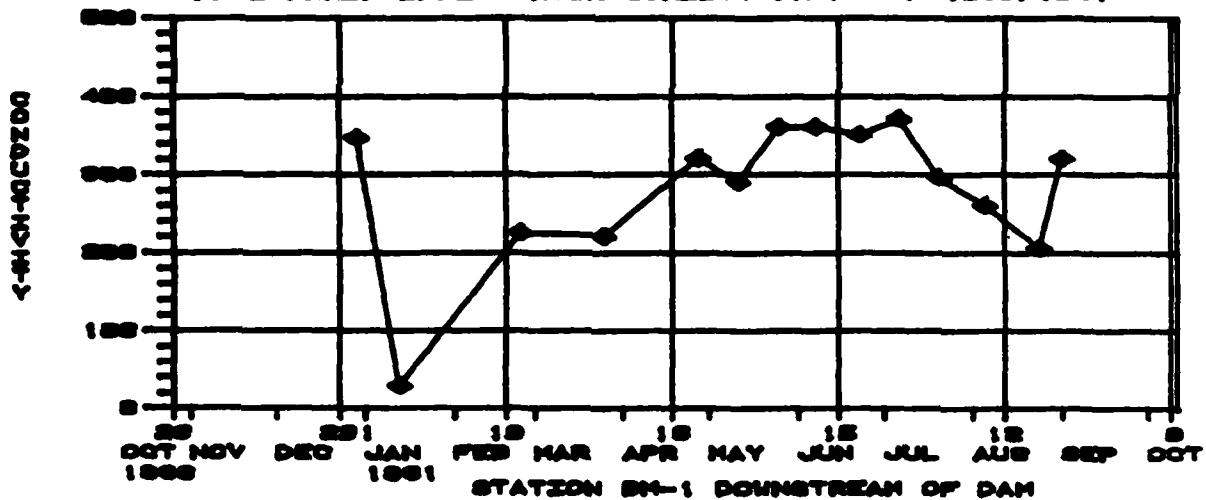
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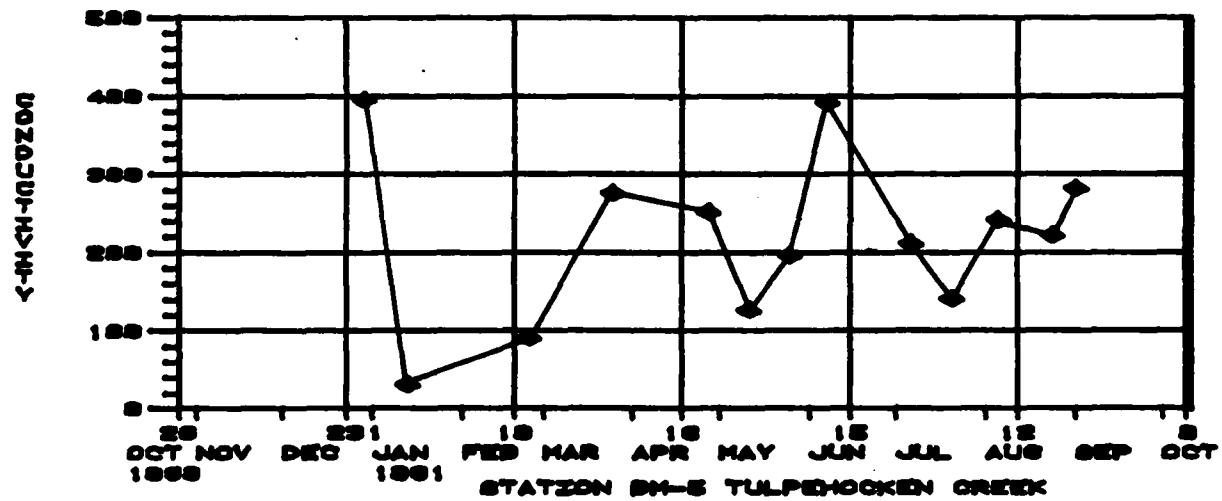
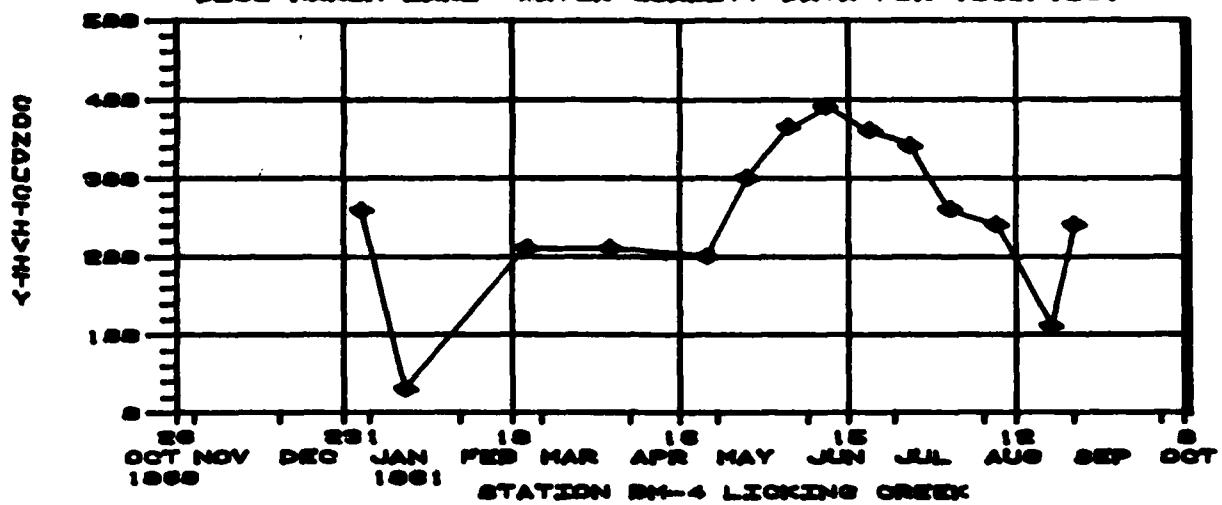
BLUE MARSH LAKE WATER QUALITY DATA FOR 1980/1981



BLUE MARSH LAKE WATER QUALITY DATA FOR 1980/1981



BLUE MARSH LAKE WATER QUALITY DATA FOR 1980/1981



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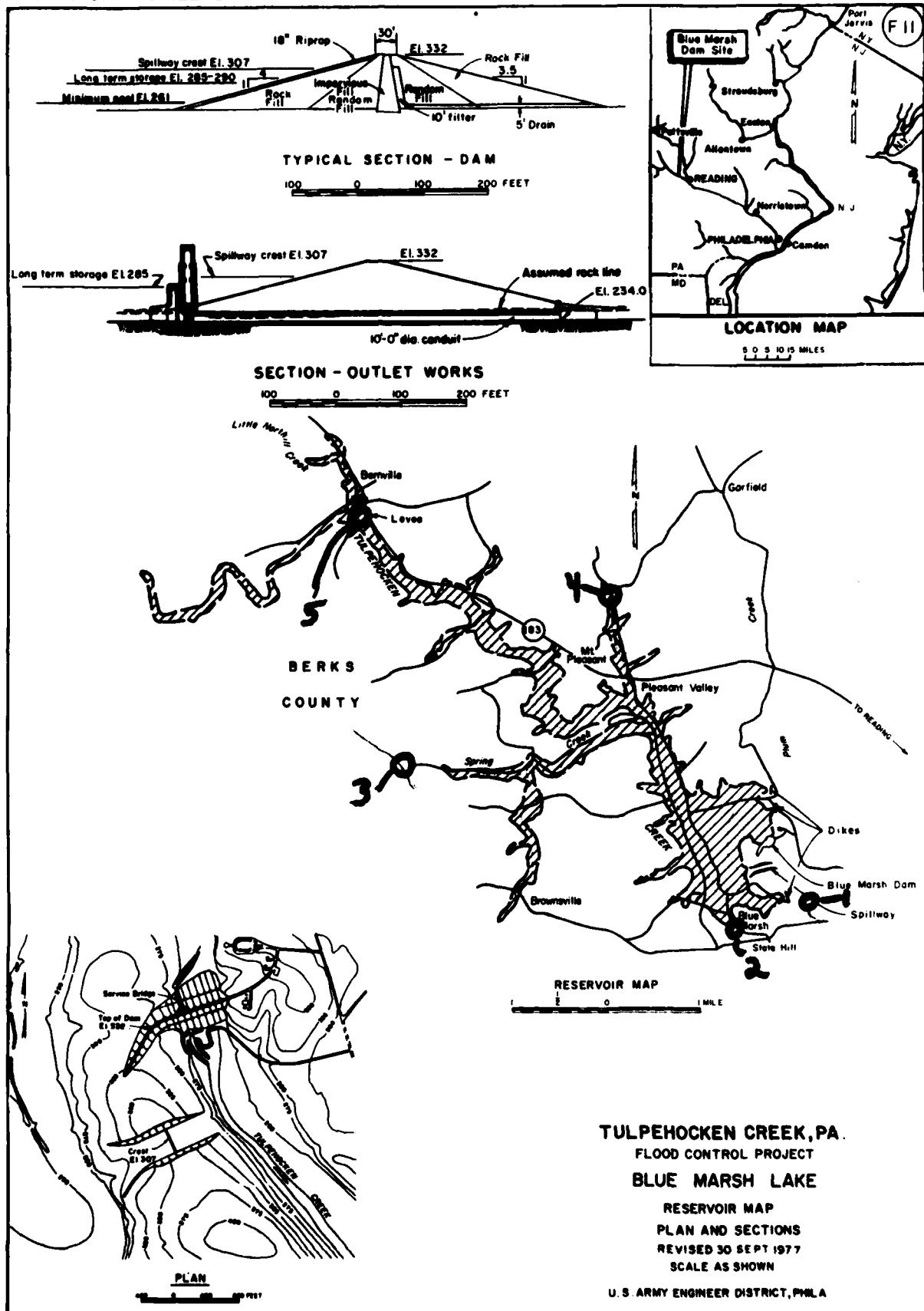


PLATE 1.

TABLE 1  
 BLUE MARSH LAKE  
 CLIMATOLOGICAL DATA 1/ - Oct 1980 - Sept 1981

<u>MONTH</u>	<u>Precp.</u> <u>(inches)</u>	<u>Total</u> <u>Snow</u> <u>(inches)</u>	<u>Avg.</u> <u>Temp.</u> <u>(oF)</u>	<u>Highest</u> <u>Temp.</u> <u>(oF)</u>	<u>Lowest</u> <u>Temp.</u> <u>(oF)</u>	<u>Days</u> <u>with</u> <u>Precp.</u>
October data not available						
NOV.	3.15	-	40.0	68	9	10
DEC.	.80	-	28.8	69	-4	3
JAN.	.55	-	22.0	49	-9	1
FEB.	3.75	-	35.3	70	7	12
MAR.	1.59	-	37.5	74	13	5
APRIL	4.96	0	52.8	80	26	16
MAY	3.62	0	61.0	89	34	8
JUNE	5.00	0	69.6	94	48	16

Data for July-Sept not available at time of report preparation.

1/ Extracted from the Monthly Summary Report - NOAA - Data collected at the Reading Station.

